US007047935B2

(12) **United States Patent**
Arai et al.

(10) **Patent No.: US 7,047,935 B2**
(45) **Date of Patent: May 23, 2006**

(54) **THROTTLE BODY HAVING INTERNALLY CONNECTED DOUBLE PIPE STRUCTURE**

(75) Inventors: **Tsuyoshi Arai**, Kariya (JP); **Naoki Hiraiwa**, Toyokawa (JP); **Hiroki Shimada**, Obu (JP)

(73) Assignee: **Denso Corporation**, (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **10/901,084**

(22) Filed: **Jul. 29, 2004**

(65) **Prior Publication Data**

US 2005/0022787 A1 Feb. 3, 2005

(30) **Foreign Application Priority Data**

Aug. 1, 2003 (JP) 2003-285068

(51) **Int. Cl.**
F02D 9/08 (2006.01)

(52) **U.S. Cl.** **123/337**; 123/399

(58) **Field of Classification Search** 123/337, 123/399, 361

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,359,977	A *	11/1994	Abbey	123/452
5,704,335	A	1/1998	Akutagawa et al.	
6,295,968	B1	10/2001	Torii et al.	
2001/0013332	A1*	8/2001	Torii et al.	123/337
2002/0152988	A1*	10/2002	Michels	123/337
2004/0040536	A1*	3/2004	Suzuki	123/337
2004/0041117	A1*	3/2004	Suzuki	251/305
2004/0154586	A1*	8/2004	Ino et al.	123/337
2004/0187844	A1*	9/2004	Torii et al.	123/337

FOREIGN PATENT DOCUMENTS

JP	9-032590	2/1997
JP	10-047520	2/1998
JP	11-132061	5/1999
JP	2001-263098	9/2001
JP	2001-303983	10/2001

* cited by examiner

Primary Examiner—John T. Kwon
(74) *Attorney, Agent, or Firm*—Nixon & Vanderhye PC

(57) **ABSTRACT**

A resinous throttle body has a bore wall part having a double pipe structure constructed with a bore inner pipe and a bore outer pipe that are connected with each other via an annular connecting part. The annular connecting part has axial board thickness set to be less than the minimum radial thickness of a portion of the bore inner pipe and a portion of the bore outer pipe that are located around the annular connecting part. Therefore, the annular connecting part can be formed to be in a thin-walled radially elongated plate shape. The annular connecting part has a radially cross-sectional length larger than its axial board thickness, so that rigidity and strength of the annular connecting part is decreased. Therefore, contraction of the bore outer pipe occurred in its molding process does not largely affect the bore inner pipe, so that a cylindrical-shaped inner periphery of the bore inner wall, which rotatably receives a disc-shaped throttle valve, can be restricted from being deformed.

13 Claims, 15 Drawing Sheets

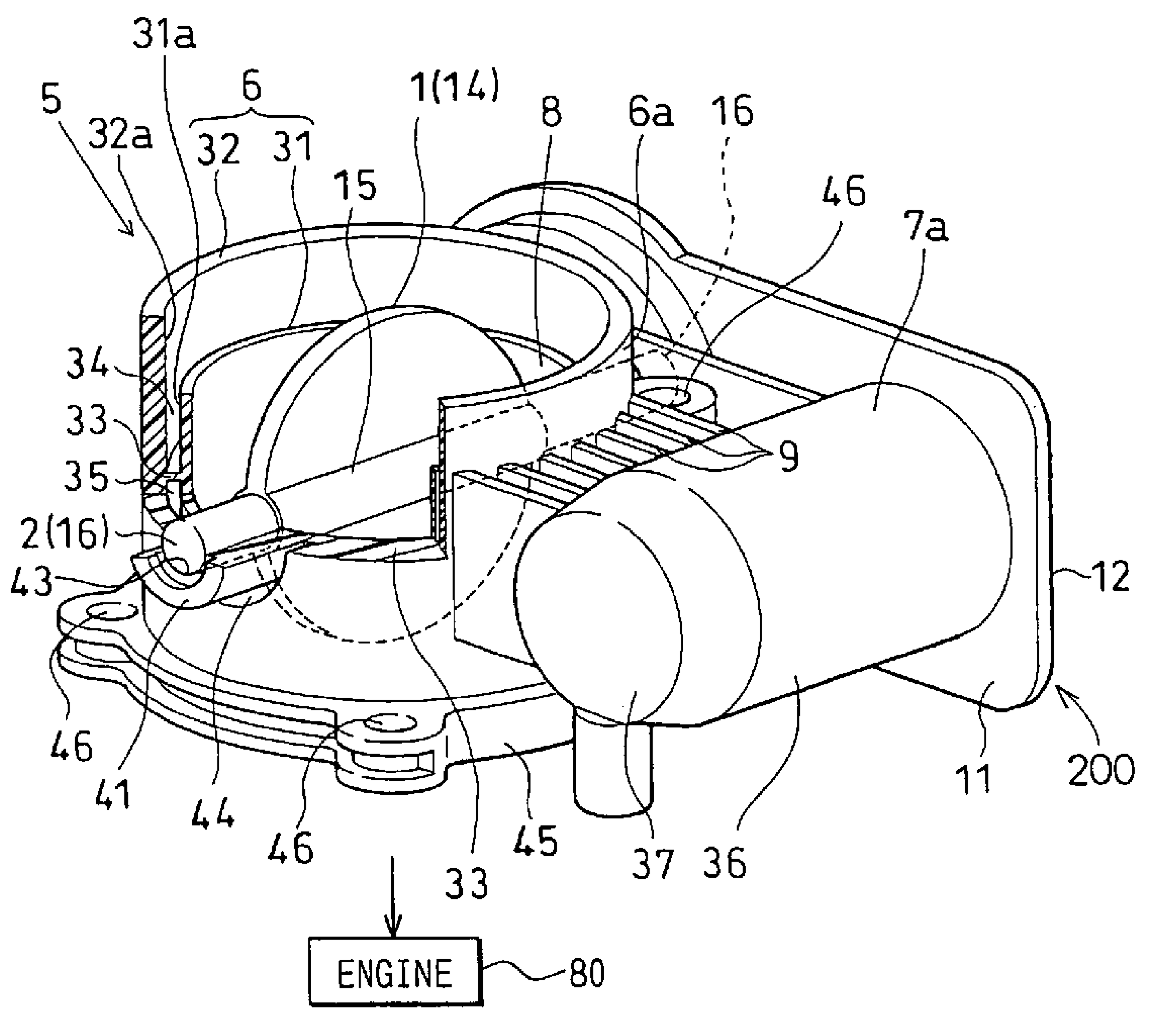


FIG. 1

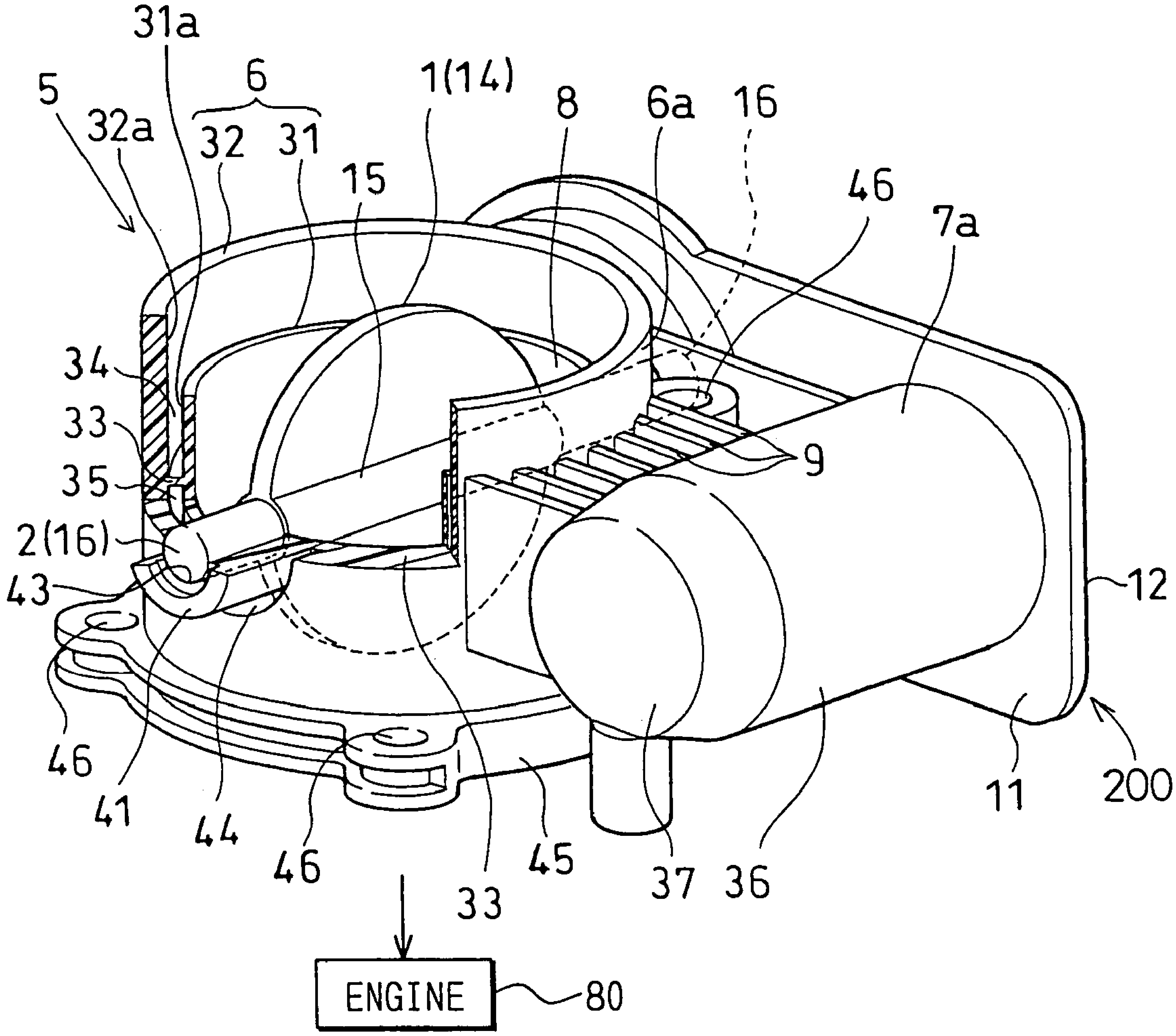

31a
5
6
32a
32
31
1(14)
8
6a
16
15
46
7a
34
33
35
9
2(16)
43
12
46
41
44
46
33
45
37
36
11
200
ENGINE
80

FIG. 2

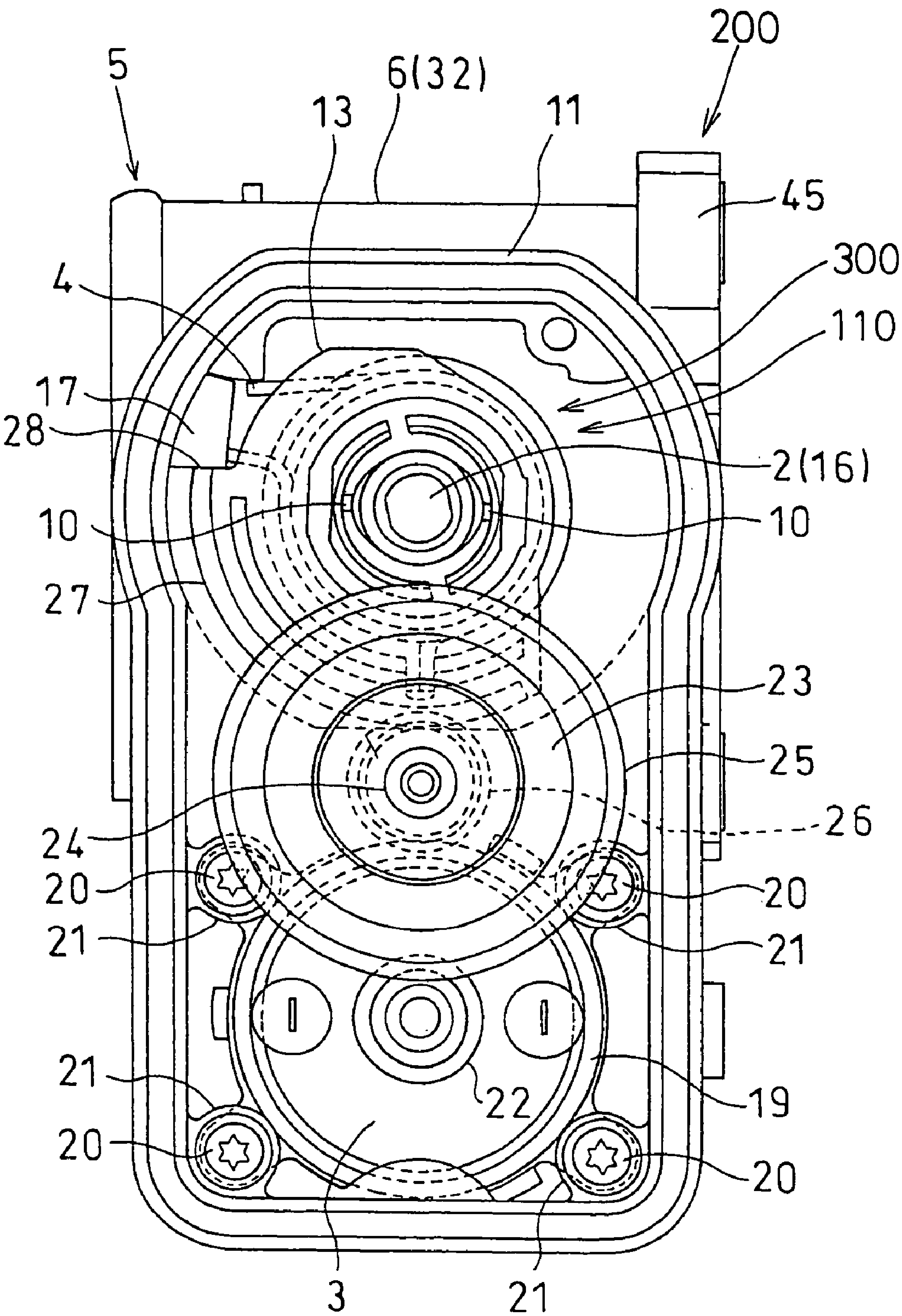

5
6(32)
13
11
200
45
300
110
4
17
28
2(16)
10
10
27
23
25
24
26
20
20
21
21
21
22
19
20
20
3
21

FIG. 3

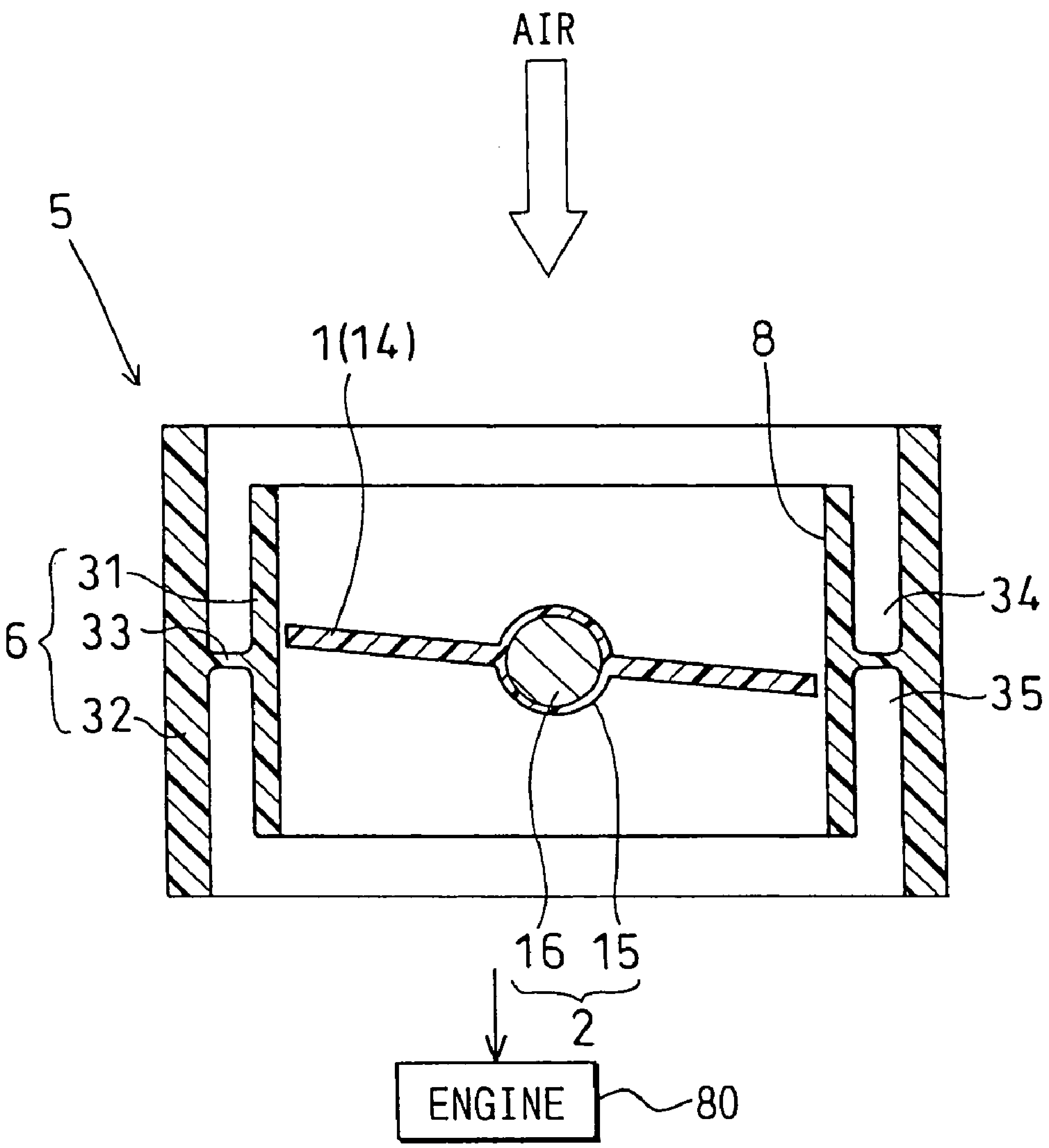


FIG. 4

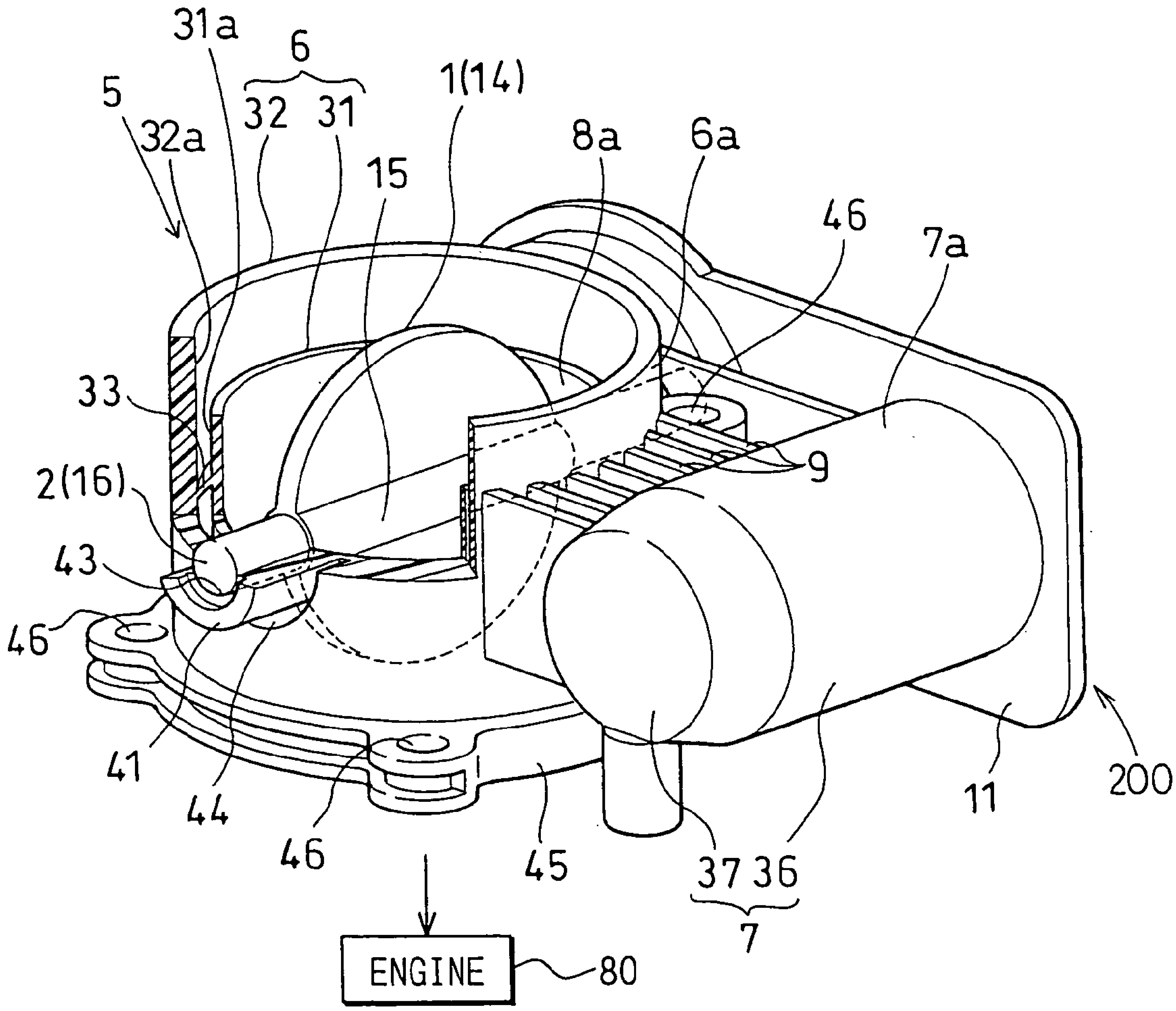
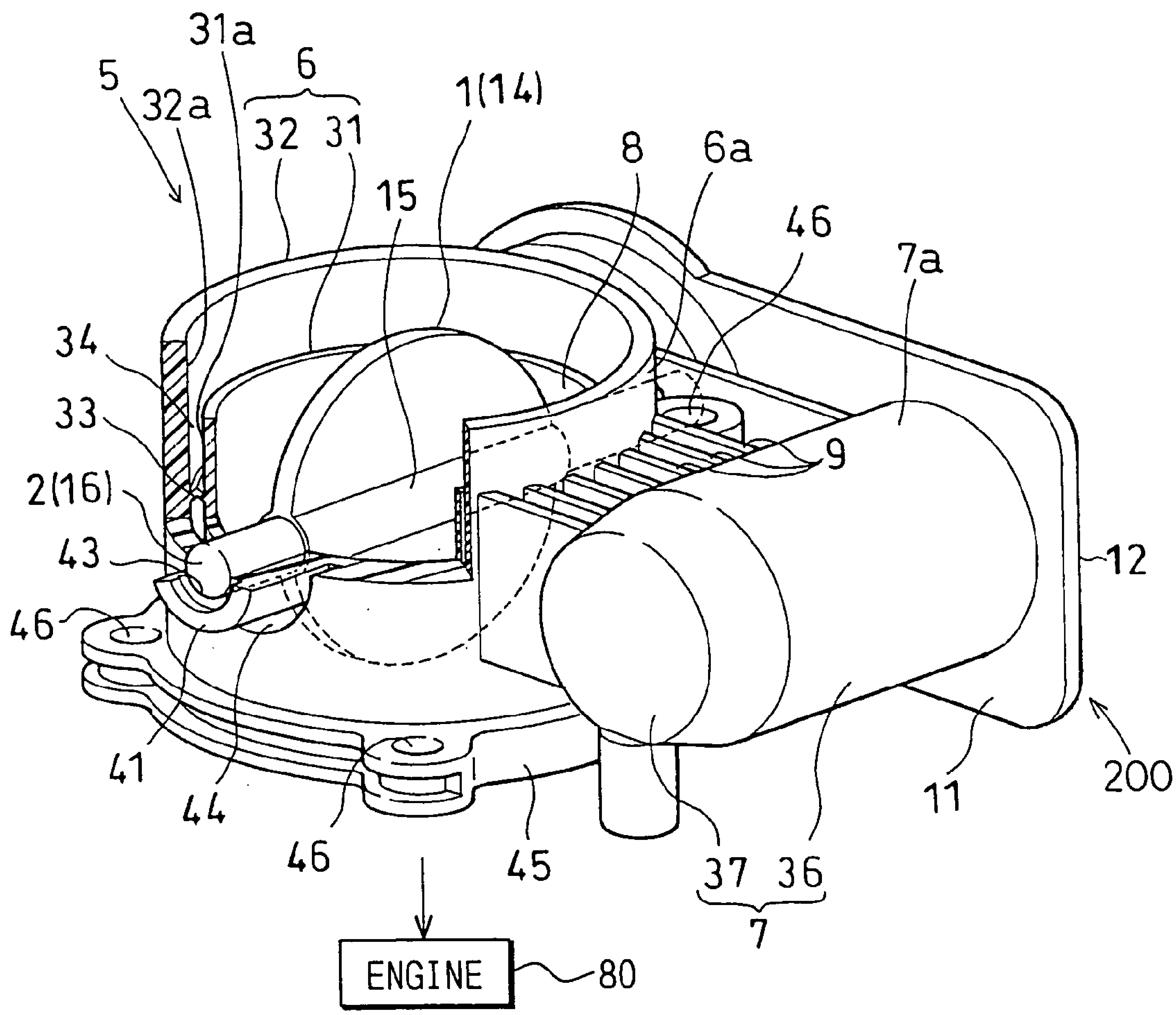

31a
6
5
32a
32
31
1(14)
15
8a
6a
46
7a
33
9
2(16)
43
46
41
44
46
45
37
36
7
11
200
ENGINE
80

FIG. 5



31a
5
32a
6
32
31
1(14)
15
8
6a
46
7a
34
33
2(16)
43
46
9
12
41
44
46
45
37
36
7
11
200
ENGINE
80

FIG. 6

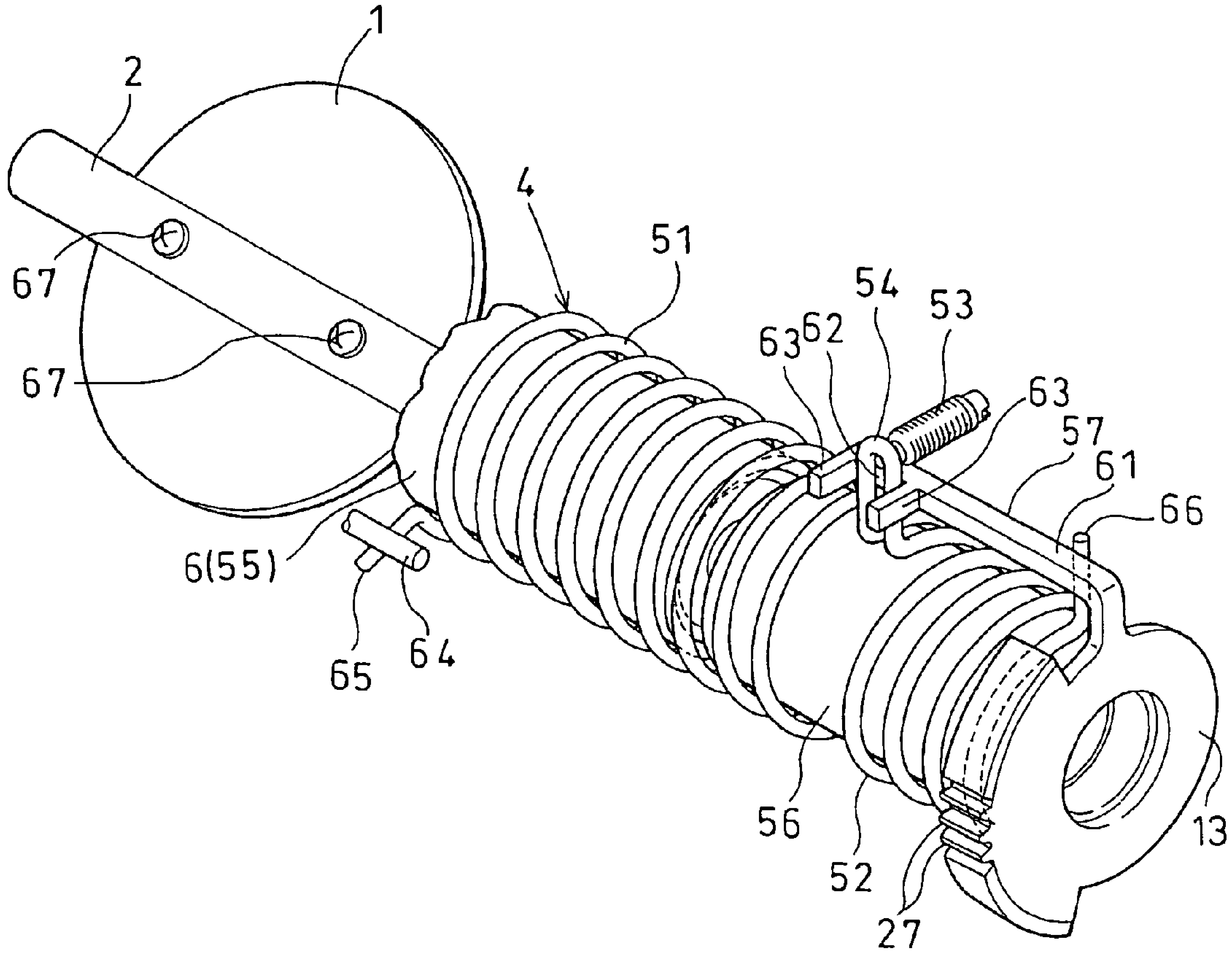
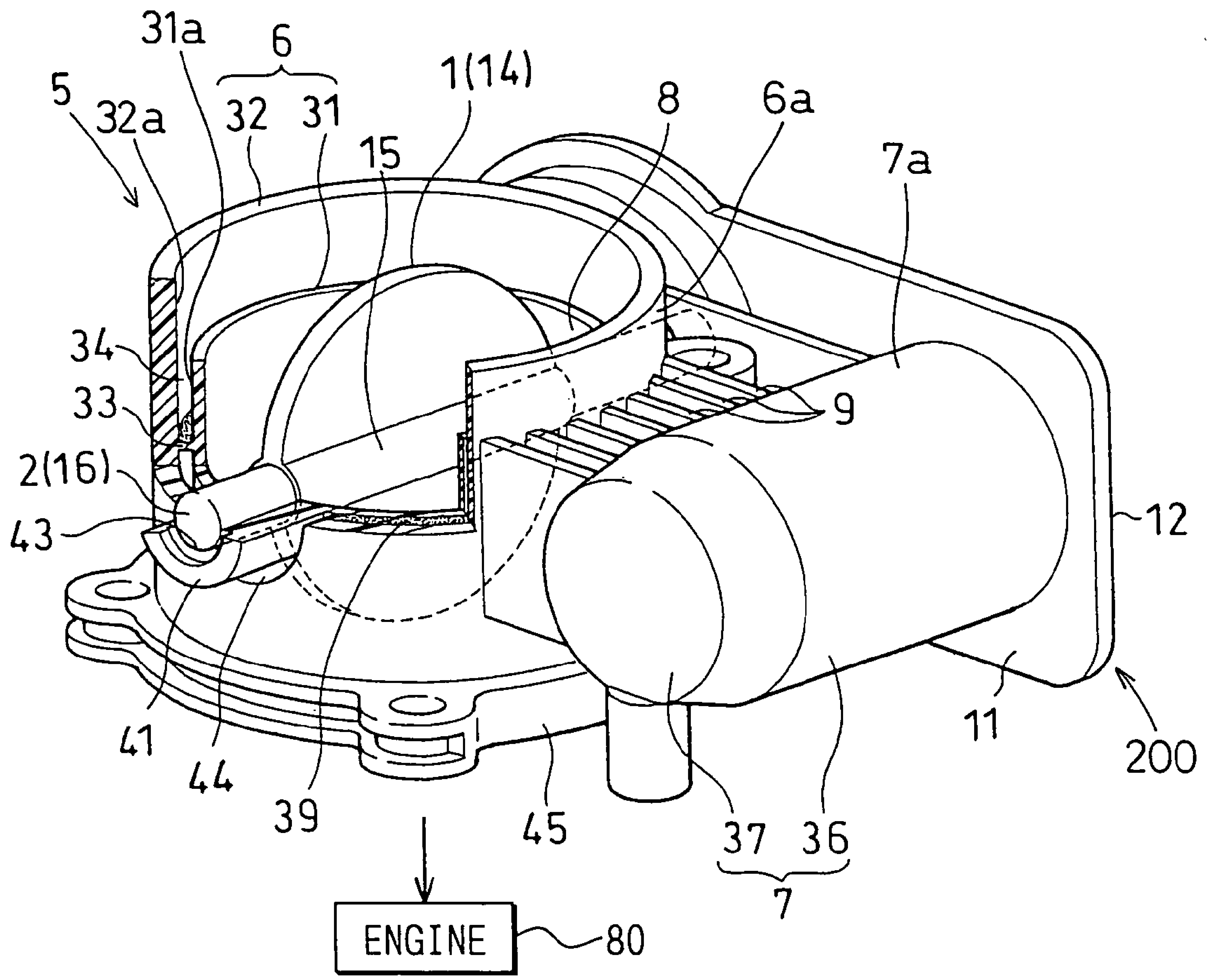


FIG. 7



31a
6
5
32a
32
31
15
1(14)
8
6a
7a
34
33
2(16)
43
9
12
41
44
39
45
37
36
7
11
200
ENGINE
80

FIG. 8A

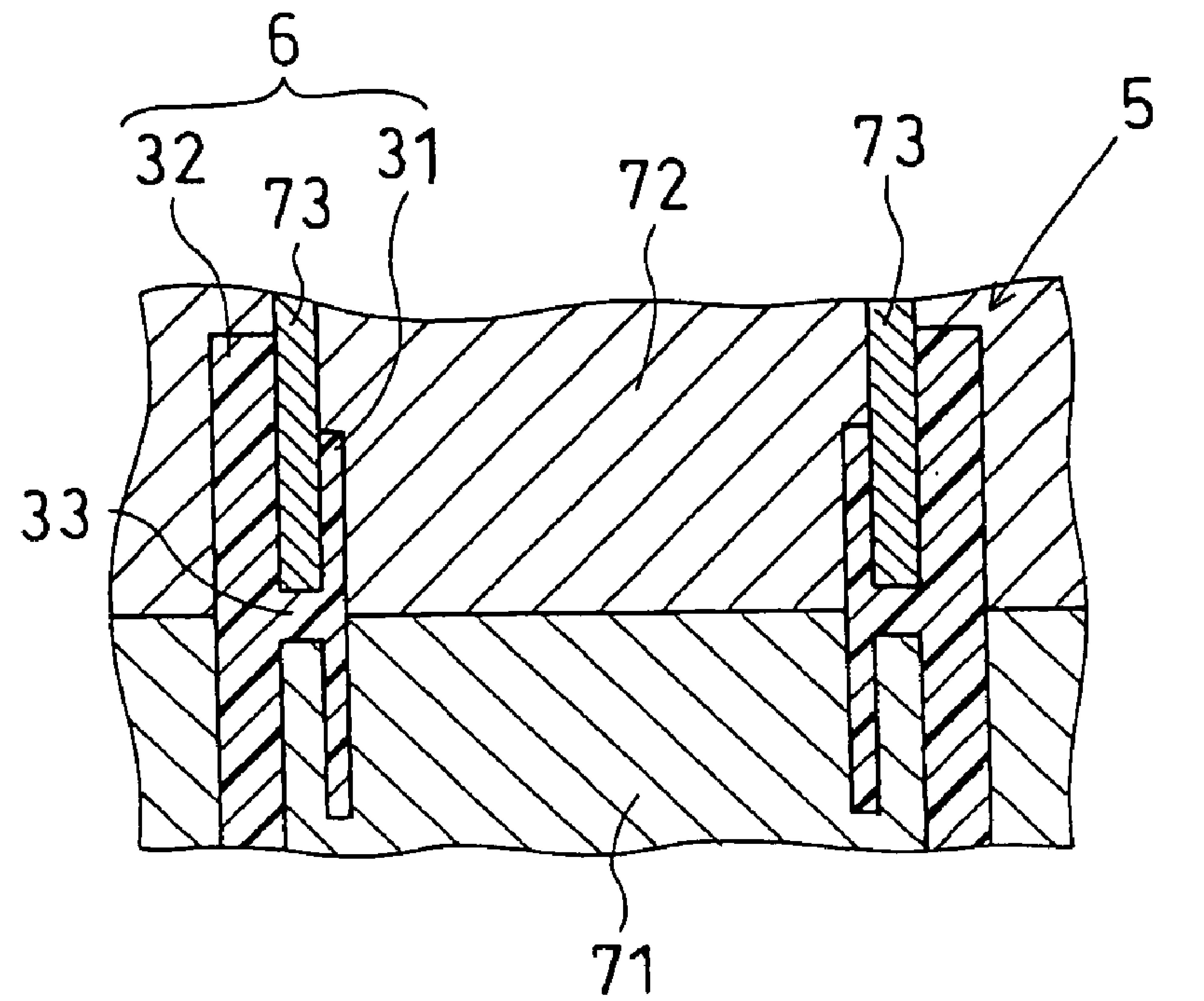


FIG. 8B

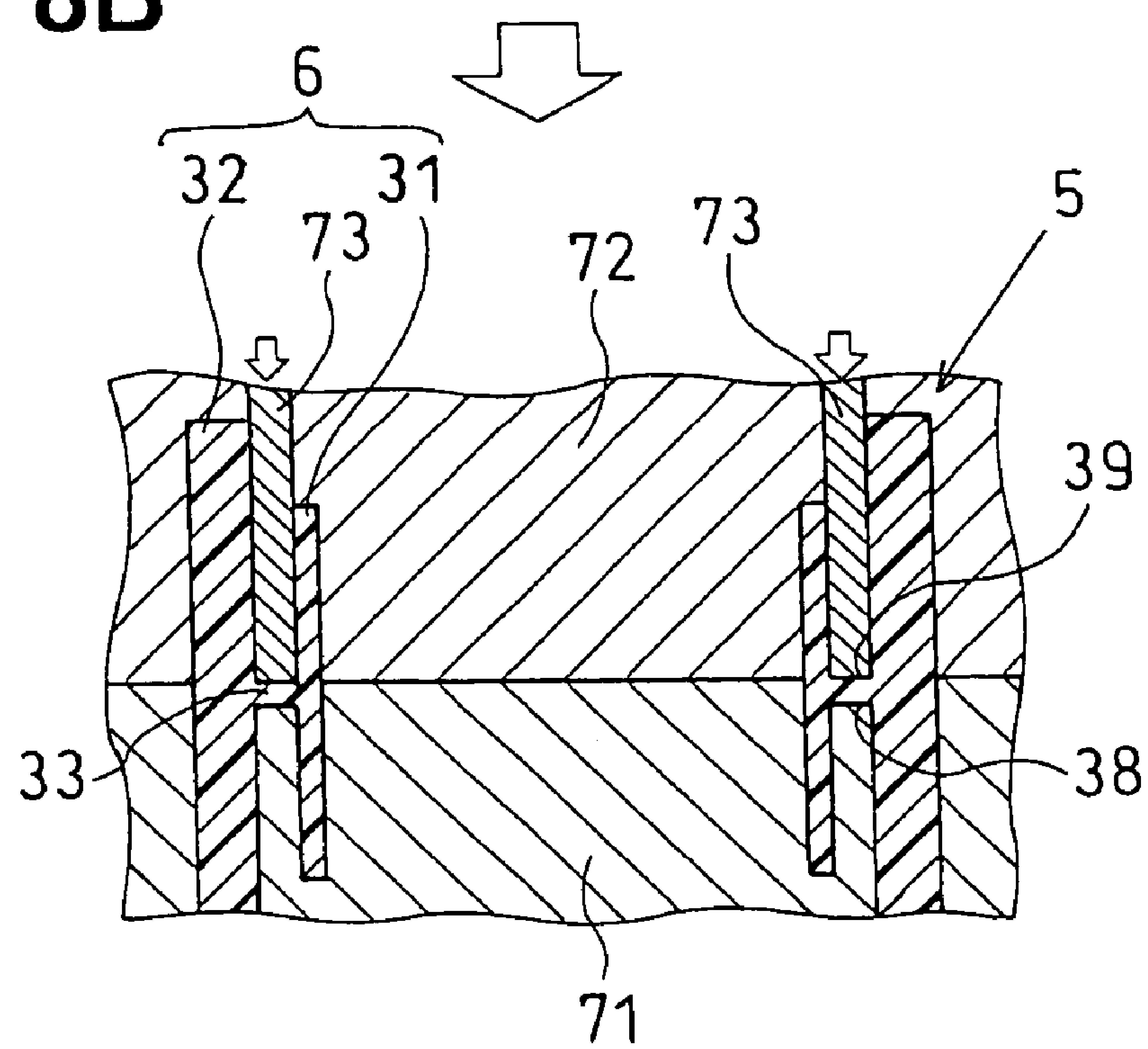


FIG. 9

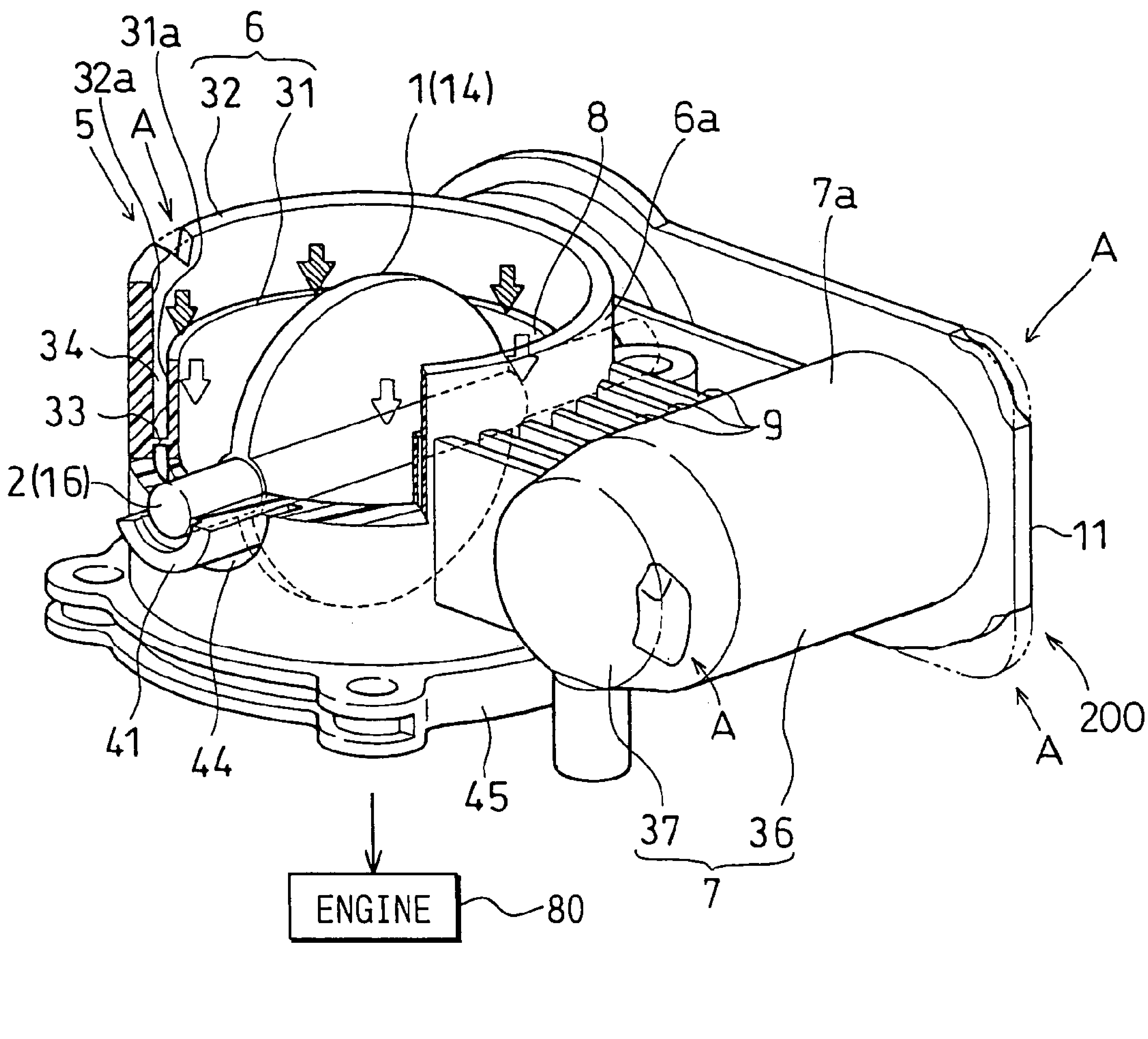

31a
6
32a
32
31
1(14)
8
6a
5
A
7a
A
34
9
33
2(16)
11
41
44
45
A
200
A
37
36
7
ENGINE
80

FIG. 10

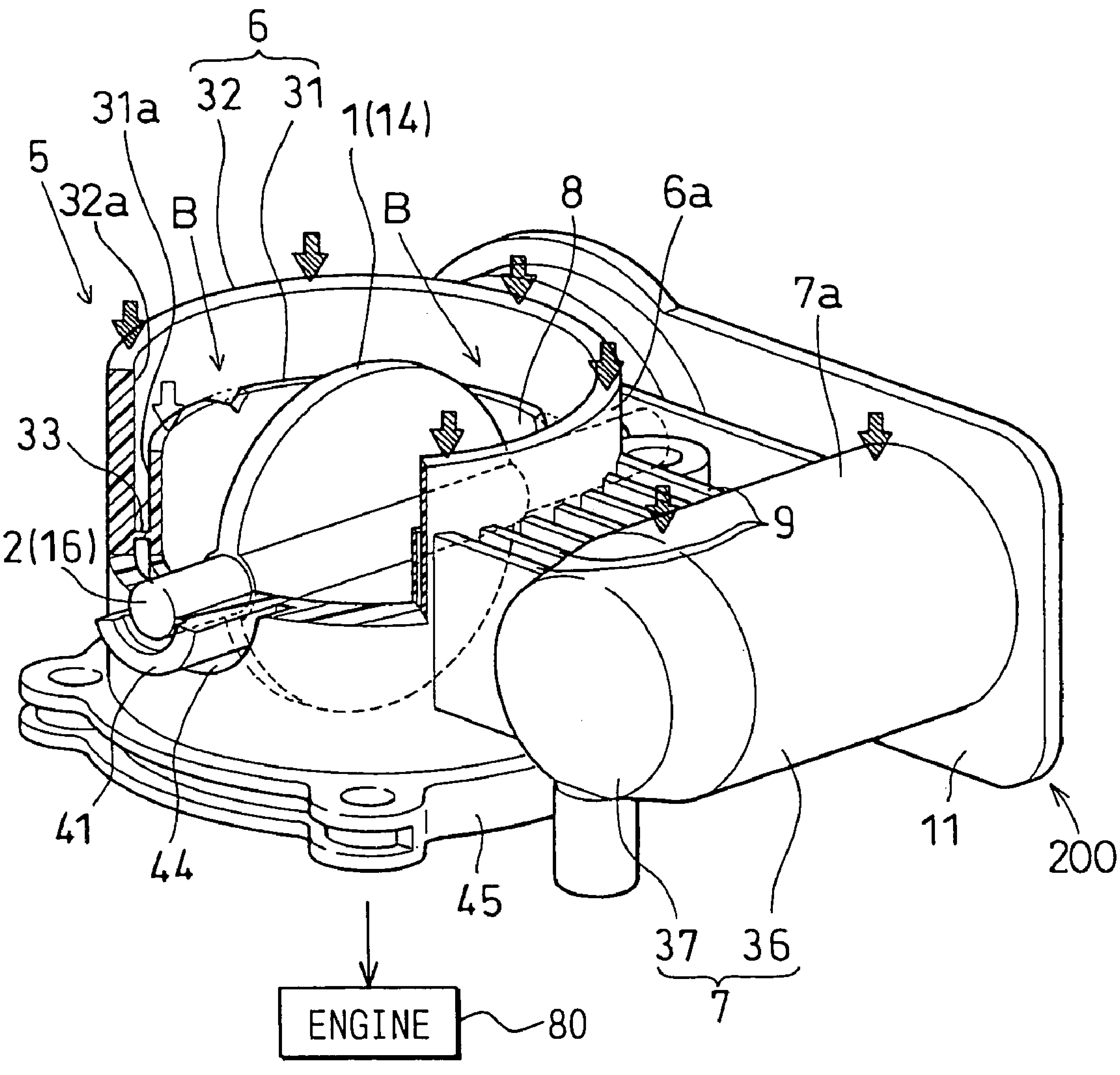

6
32
31
31a
1(14)
5
32a
B
B
8
6a
7a
33
9
2(16)
41
44
45
11
200
37
36
7
ENGINE
80

FIG. 11

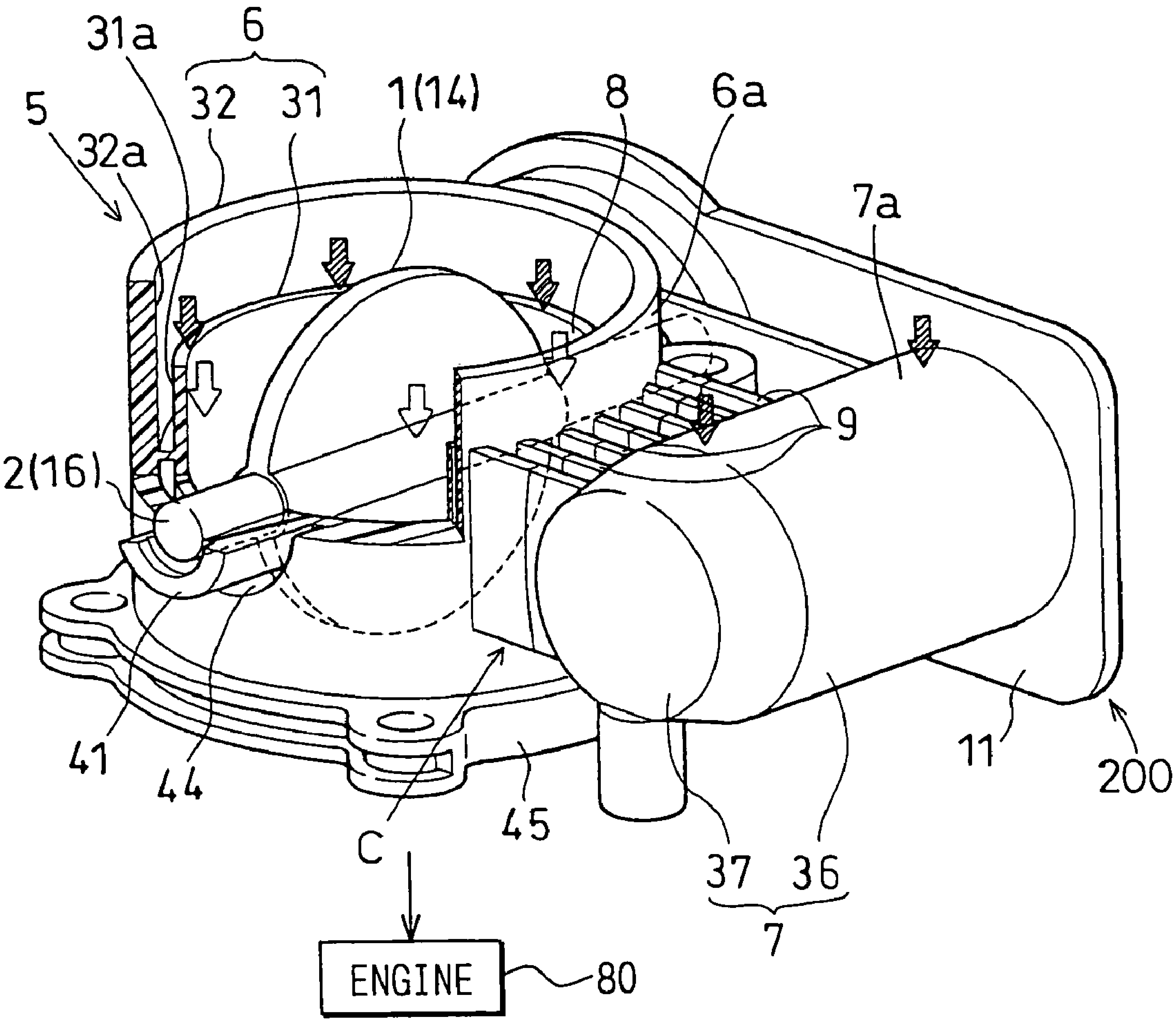


FIG. 12

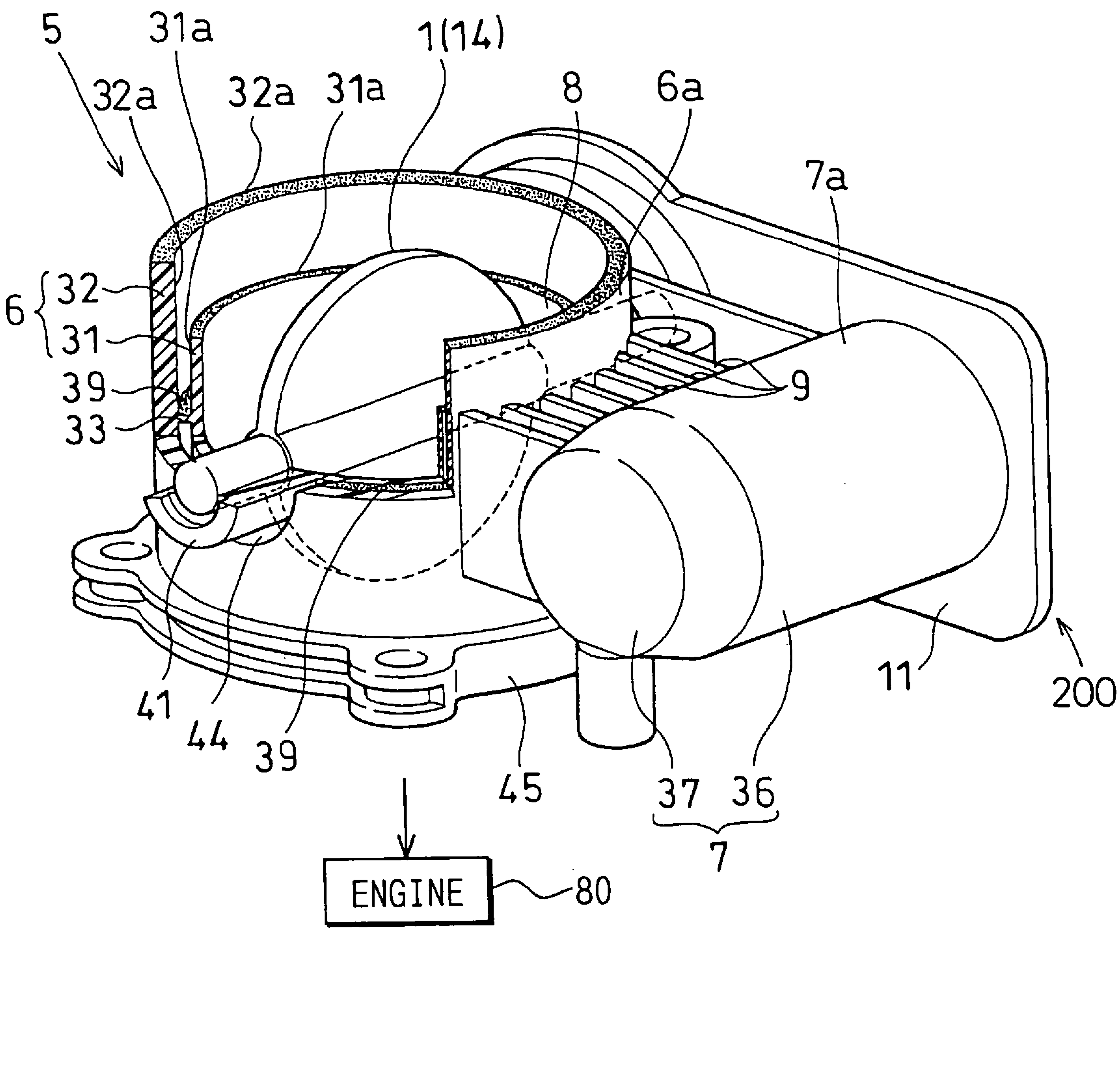

5
31a
32a
32a
31a
1(14)
8
6a
7a
6
32
31
39
33
9
41
44
39
45
37
36
7
11
200
ENGINE
80

FIG. 13
RELATED ART

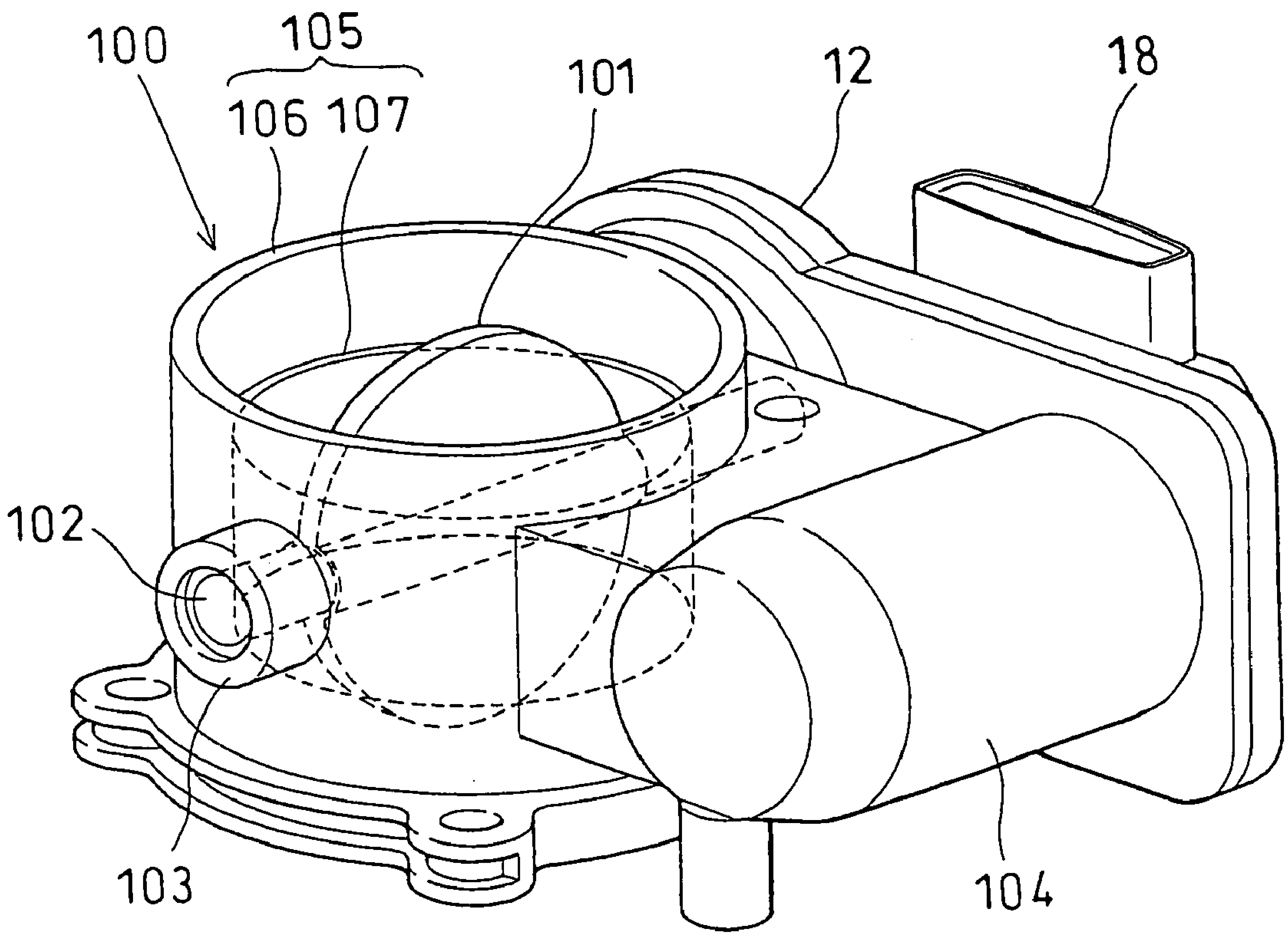


FIG. 14

RELATED ART

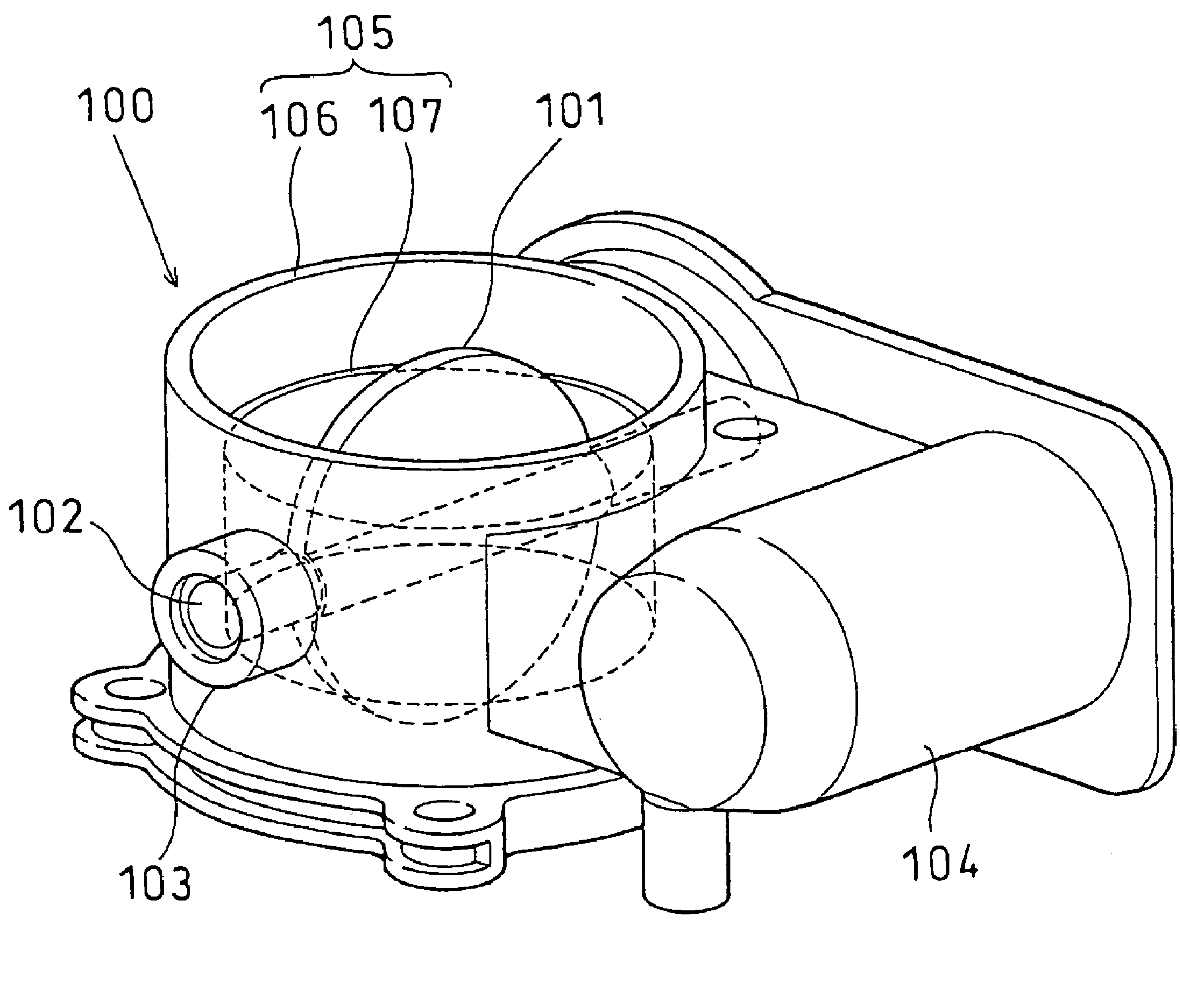
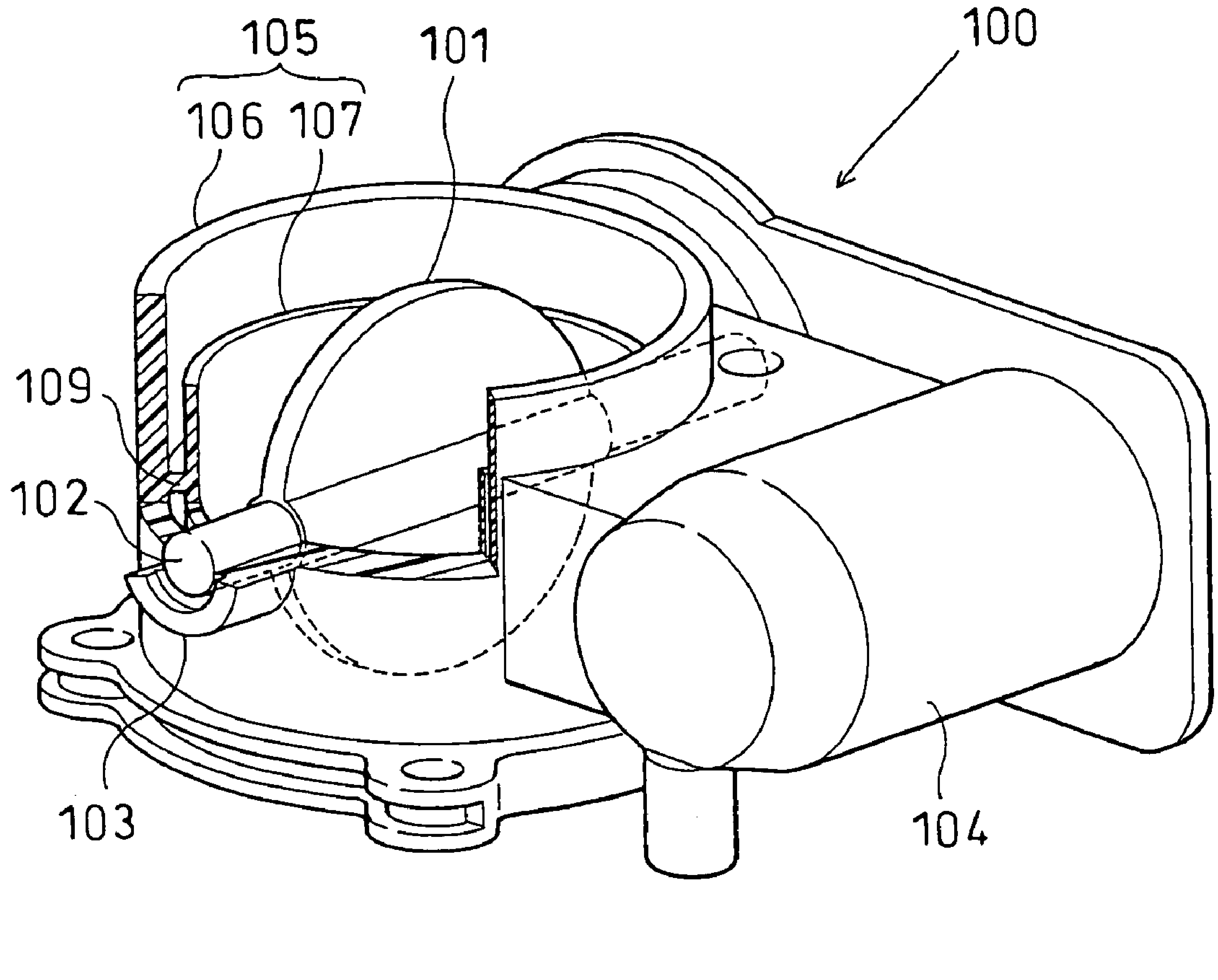


FIG. 15

RELATED ART



THROTTLE BODY HAVING INTERNALLY CONNECTED DOUBLE PIPE STRUCTURE

CROSS REFERENCE TO RELATED APPLICATION

This application is based on and incorporates herein by reference Japanese Patent Application No. 2003-285068 filed on Aug. 1, 2003.

FIELD OF THE INVENTION

The present invention relates to a throttle body including a bore wall part having a double-pipe structure formed with a substantially cylindrical-shaped bore inner pipe, a substantially cylindrical-shaped bore outer pipe and an annular connecting part that are integrally molded of a resinous material. Especially, the present invention relates to an electrically controlled throttle apparatus, in which a motor is driven to control a rotation angle of a throttle valve that is rotatably received in the throttle body. Thus, an amount of intake air flowing into an internal combustion engine is controlled in accordance with an operating amount of a driver in a vehicle.

BACKGROUND OF THE INVENTION

Conventionally, a drive unit such as a motor is used in an electrically controlled throttle apparatus to control a throttle valve to be in a predetermined throttle position in accordance with an accelerator position of an accelerator pedal stepped by a driver. According to an electrically controlled throttle apparatus disclosed in JP-A 10-047520, JP-A 2001-263098 and JP-A 2001-303983, a bore wall part and a motor housing part are integrally molded of a resinous material to construct a throttle body. Besides, according to JP-A 09-032590 and JP-A 11-132061, a throttle body has an outer pipe and an inner pipe that are coaxially arranged with each other to form an integrally molded double-pipe structure, in which the inner pipe receives a throttle valve.

The electrically controlled throttle apparatus drives a motor to control a throttle position of a throttle valve in accordance with an operating amount of a driver. In this throttle apparatus, circularity of an inner periphery of the substantially cylindrical bore wall part of the resinous throttle body has a large influences with an airtightness of the throttle valve, when the throttle valve is in its full close position. Besides, when the substantially cylindrical bore wall part, a substantially cylindrical valve bearing part and a substantially cylindrical motor housing part are integrally molded of a resinous material, contraction may arise in the valve bearing part and the motor housing part during its molding process. Accordingly, the inner periphery of the bore wall part is apt to be deformed due to the contraction of the valve bearing part and the motor housing part.

FIGS. **13** and **14** are perspective views showing an example of a throttle apparatus. The throttle apparatus has a throttle body **100** that is integrally molded of a resinous material with a substantially cylindrical valve bearing part **103**, a substantially cylindrical motor housing part **104** and a bore wall part **105**. The valve bearing part **103** rotatably supports one end side of the throttle shaft **102** that integrally rotates with a throttle valve **101**. The motor housing part **104** receives a driving motor that rotates the throttle shaft **102** and the throttle valve **101** integrally. The bore wall part **105** internally forms an air intake passage, through which intake air flows into an internal combustion engine. The bore wall part **105** has a double pipe structure, in which a bore inner pipe **107** is coaxially arranged inside a bore outer pipe **106**. The outer periphery of the bore inner pipe **107** and the inner periphery of the bore outer pipe **106** are connected with each other via an annular connecting part **109**.

FIG. **15** is a partially cross-sectional perspective view showing the throttle apparatus. The bore wall part **105** having a double pipe structure is integrally molded of a resinous material. The annular connecting part **109** may has radial thickness that is less than its board thickness (axial board thickness) in its axial direction. The annular connecting part **109** has axial board thickness that may be greater than radial thickness of the bore inner pipe **106**. In these cases, contraction of the bore outer pipe **106** in its molding process may cause deformation of the inner periphery of the bore inner pipe **107**. Alternatively, the valve bearing part **103** and the sidewall of the bore outer pipe **106** may be directly connected with each other. In this connecting structure, contraction of a portion in the bore outer pipe **106** around the valve bearing part **103** may cause deformation of the inner periphery of the bore inner pipe **107**. Alternatively, the sidewall of the motor housing part **104** and the sidewall of the bore outer pipe **106** may be directly connected with each other. In this connecting structure, contraction of a portion around the motor housing part **104** may cause deformation of the inner periphery of the bore inner pipe **107**. Accordingly, when the motor housing part **104**, the valve bearing part **103** and the bore wall part **105** are integrally molded of a resinous material, circularity of the inner periphery of the bore inner pipe **107** may be degraded due to contraction of the bore outer pipe **106** and the motor housing part **104**. In this case, interference may arise between the throttle valve **101** and the bore inner pipe **107** when the throttle valve **101** rotates from its full close position to its full open position. Furthermore, a gap, which is formed between the inner periphery of the bore inner pipe **107** and the outer circumferential periphery of the throttle valve **101** when the throttle valve **101** is in its full close position, may become larger than a predetermined amount. Accordingly, airtightness may be degraded when the throttle valve **101** is in its full close position, and leakage of intake air increases in an idling operation of the engine.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a throttle body including both of a bore inner pipe and a bore outer pipe connected with each other via an annular connecting part having a shape restricting deformation of the inner periphery of the bore inner pipe caused by contraction of at least the bore outer pipe. It is another object of the present invention to provide a throttle body, in which the inner periphery of the bore inner pipe can be restricted from deformation caused by contraction of the bore outer pipe or the motor housing part. Thus, the throttle valve can be restricted from occurrence of a failure, and airtightness of the throttle apparatus can be maintained when the throttle valve is in the full close position.

According to the present invention, a throttle body, which receives a throttle valve, includes a bore wall part having a double-pipe structure. The bore wall part includes an inner pipe, an outer pipe and an annular connecting part. The inner pipe rotatably receives the throttle valve. The outer pipe is arranged on a radially outer side of the inner pipe to define a cylindrical space with an outer periphery of the inner pipe therebetween. The annular connecting part connects the inner pipe and the outer pipe, such that the annular connecting part partitions and blocks substantially entirely over a circumferential area of the cylindrical space defined between the bore inner pipe and the bore outer pipe.

The inner pipe, the outer pipe and the annular connecting part are integrally molded of a resinous material. The axial thickness of the annular connecting part is less than the minimum thickness of the inner pipe in its radial direction and the minimum thickness of the outer pipe in its radial direction. Alternatively, the axial thickness of the annular connecting part is less than its radial thickness. The annular connecting part partially blocks substantially entirely over the circumferential area of the cylindrical space formed between the inner pipe and the outer pipe. The inner pipe of the bore wall part has a substantially cylindrical inner periphery that defines an intake air passage through which intake air passes. The throttle valve opens and closes the intake air passage defined by the inner periphery of the inner pipe of the bore wall part.

An integrally molding method of a throttle body of a resinous material includes clamping the molding dies, injecting molten filler, and applying predetermined pressure to the filler. The molding dies are clamped with each other during a first clamping process. Molten filler is injected into molding dies clamping with each other to fill a first cavity having an internal volume greater than a volume of the molded throttle body defined in the molding dies during an injection-filling process. Predetermined pressure is applied to the filler filled in the molding dies during a pressure holding process. The thickness of the annular connecting part in an axial direction of the annular connecting part becomes greater than the minimum thickness of the inner pipe in its radial direction and the minimum thickness of the outer pipe in its radial direction. The first clamping process is performed during at least one of the injection-filling process and the pressure holding process. The molding method of the throttle body includes steps of cooling the filler, and refilling molten filler. The filler, to which the predetermined pressure is applied, is cooled during the pressure holding process, and molten filler is refilled into the first cavity by an amount, which is equivalent to a reduced volume of the cooled filler contracted by the cooling, during the pressure holding process. The molding dies clamp with each other to define a second cavity that has an internal volume substantially the same as the volume of the molded throttle body.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages of the present invention will become more apparent from the following detailed description made with reference to the accompanying drawings. In the drawings:

FIG. **1** is a perspective partially cross-sectional view showing an electrically controlled throttle apparatus according to a first embodiment of the present invention;

FIG. **2** is a front view showing components received in a gearbox of a throttle body provided in the electrically controlled throttle apparatus;

FIG. **3** is a schematic cross-sectional side view showing a double-pipe structure of a bore wall part provided in the throttle body;

FIG. **4** is a perspective partially cross-sectional view showing an electrically controlled throttle apparatus according to a second embodiment of the present invention;

FIG. **5** is a perspective partially cross-sectional view showing an electrically controlled throttle apparatus according to a third embodiment of the present invention;

FIG. **6** is a perspective view showing an inner mechanism of the electrically controlled throttle apparatus according to a fourth embodiment of the present invention;

FIG. **7** is a perspective partially cross-sectional view showing an electrically controlled throttle apparatus according to a fifth embodiment of the present invention;

FIGS. **8**A and **8**B are schematic cross-sectional side views showing an injection press molding process of the throttle body according to the fifth embodiment;

FIG. **9** is a perspective partially cross-sectional view showing an electrically controlled throttle apparatus including a molded throttle body according to a first example;

FIG. **10** is a perspective partially cross-sectional view showing an electrically controlled throttle apparatus including a molded throttle body according to a second example;

FIG. **11** is a perspective partially cross-sectional view showing an electrically controlled throttle apparatus including a molded throttle body according to a third example;

FIG. **12** is a perspective partially cross-sectional view showing the electrically controlled throttle apparatus molded using an injection press molding process according to a sixth embodiment of the present invention;

FIGS. **13** and **14** are perspective views showing an electrically controlled throttle apparatus according to a related art; and

FIG. **15** is a perspective partially cross-sectional view showing the electrically controlled throttle apparatus according to the related art.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

First Embodiment

As shown in FIGS. **1** to **3**, an electrically controlled throttle apparatus is constructed with a throttle valve **1**, a throttle shaft **2**, a driving motor **3**, a coil spring **4**, reduction gears **300**, an actuator case **200**, a throttle body **5** and an ECU (electronic control unit). The throttle valve **1** controls an amount of intake air flowing into an internal combustion engine **80**. The throttle shaft **2** constructs a shaft part of the throttle valve **1**. The driving motor **3** rotates the throttle shaft **2**, so that the throttle valve **1** is rotated in an open direction, in which the throttle valve **1** is opened to be in a full throttle position (full open position), or a close direction, in which the throttle valve **1** is closed to be in an idling position (full close position). The driving motor **3** serves as an actuator (valve operating means). The coil spring **4** urges the throttle shaft **2**, so that the throttle valve **1** is rotated in the close direction. The reduction gears (power transmission unit) **300** transmit rotation power of the driving motor **3** to the throttle shaft **2** in order to integrally rotate the throttle shaft **2** and the throttle valve **1**. The actuator case **200** rotatably receives the reduction gears **300**. The throttle body **5** internally forms an air intake passage introducing intake air into each cylinders of the engine **80**. The ECU (electronic control unit) electrically controls the driving motor **3**. The ECU is connected to an accelerator position sensor (not shown) that converts an operation degree (accelerator operation amount) of an accelerator pedal stepped by a driver into an electronic signal (accelerator position signal) in order to output the accelerator position signal to the ECU. The accelerator position signal represents the accelerator operation amount. The electrically controlled throttle apparatus has a throttle position sensor **110** that converts an opening degree of the throttle valve **1** into an electronic signal (throttle position signal) in order to output the throttle position signal to the

ECU. The throttle position signal represents an opening degree of the throttle valve **1**. The ECU performs PID (proportional, integral and differential [derivative]) feedback control with respect to the driving motor **3** in order to eliminate deviation between the throttle position signal transmitted from the throttle position sensor **110** and the accelerator position signal transmitted from the accelerator position sensor.

The throttle position sensor **110** is constructed with permanent magnets **10**, yokes (not shown), a hall element (not shown), a terminal (not shown), a stator (not shown) and the like. The permanent magnets **10** are separated rectangular magnets used for generating a magnetic field. The yokes are constructed with separated substantially arc-shaped pieces, and are magnetized by the permanent magnets **10**. The hall element is integrally provided with a sensor cover (FIG. **13**) **12** to be opposed to the separated permanent magnets **10**. The terminal is constructed with a conductive metallic thin plate that connects the hall element to the ECU, which is externally provided with respect to the throttle position sensor **110**. The stator is made of a ferrous metallic material for concentrating magnetic flux into the hall element. The separated permanent magnets **10** and the separated yokes are secured to the inner periphery of a valve gear **13**, which constructs the reduction gears **300**, using glue or the like.

The throttle valve **1** is a butterfly-type rotary valve for controlling an amount of intake air introduced into the engine **80**. The throttle valve **1** having a substantially disc shape is integrally molded with the outer periphery of a valve supporting portion of the throttle shaft **2**, so that the throttle valve **1** and the throttle shaft **2** can integrally rotate. The throttle valve **1** is made of a thermo stable resinous material, such as PPS (poly phenylene sulfide), PBTG30 (poly butylene terephthalate including grass fiber by 30%), PA (polyamide), PP (polypropylene) or PEI (polyether imide). A stiffening rib (not shown) is integrally molded on one plane face, e.g., upstream side of the intake airflow direction with respect to the resinous disc part (disc-shaped part) **14**, or both plane faces of the disc-shaped part **14** of the throttle valve **1** for reinforcing the disc-shaped part **14**.

Both of the end sides of the throttle shaft **2** are rotatably supported by a first valve bearing **41** and a second valve bearing (not shown) of the throttle body **5** to be slidable each other. The axial direction of the throttle shaft **2** is arranged to be substantially perpendicular to the central axial direction of the bore wall part **6** of the throttle body **5**, and is arranged to be substantially in parallel with the central axial direction of a substantially cylindrical shaped motor housing part **7**. Here, the throttle shaft **2** is constructed with a resinous shaft part **15** and a metallic shaft part **16**, in this embodiment. The resinous shaft part **15** serves as a valve supporting portion for supporting the throttle valve **1**. The metallic shaft part **16** is formed inside of the resinous shaft part (cylindrical part) **15** by insert molding to reinforce the resinous shaft part **15**.

The resinous shaft part **15** is formed in a substantially cylindrical shape. The resinous shaft part **15** is made of a thermo stable resinous material, such as PPS, PBTG30, PA, PP or PEI, as well as the resinous disc part **14** of the throttle valve **1**. The metallic shaft part **16** is formed in a round-bar shape, and is made of a metallic material such as stainless steel. One end portion of the metallic shaft part **16** of the throttle shaft **2** on the left side end in FIG. **1** exposes to the outer peripheral side of the throttle shaft **2** in order to serve as a first bearing sliding part that rotatably slides with respect to the first valve bearing **41** of the throttle body **5**. The valve gear **13** constructing the reduction gears **300** is integrally provided on the other end portion of the metallic shaft part **16** of the throttle shaft **2** on the right side end in FIG. **1**. The other end side of the resinous shaft part **15** of the throttle shaft **2** on the right side end in FIG. **1** exposes to the outer peripheral side of the throttle shaft **2** in order to serve as a second bearing sliding part (not shown) that rotatably slides with respect to a second valve bearing (not shown) of the throttle body **5**.

The actuator case **200** is constructed with a gearbox part (gear housing part, case body) **11** and a sensor cover (gear cover, cover) **12**. The gearbox part **11** is integrally molded with an outer periphery of the bore wall part **6** of the throttle body **5** of the resinous material. The sensor cover **12** supports the hall element of the throttle position sensor **110**, the terminal and the stator. The sensor cover **12** covers the opening side of the gearbox part **11**.

The gearbox part **11** is made of the same resinous material as that of the bore wall part **6**, and is molded in a predetermined shape to construct a gear chamber that rotatably receives the reduction gears **300**. A full-close stopper **17** is integrally molded with the inner wall of the gearbox part **11** of the resinous material, for restricting rotation of the throttle valve **1** at the idling position, i.e., full close position of the throttle valve **1**. Here, a full-open stopper may be integrally molded with the inner wall of the gearbox part **11** for restricting rotation of the throttle valve **1** at the full-throttle position, i.e., full open position of the throttle valve **1**.

The sensor cover **12** is formed in a predetermined shape using a resinous material such as thermo plastic, in order to electrically insulate between terminals of the throttle position sensor **110** and power-supply terminals of the driving motor **3**. The sensor cover **12** has an engaging part that engages with a corresponding engaged part, which is formed on the opening side of the gearbox part **11** of the throttle body **5**, each other. The engaging part of the sensor cover **12** and the engaged part of the gearbox part **11** are connected using a rivet, a screw (not shown), or are thermally swaged with each other, for example. A substantially cylindrical shaped receptacle **18** (FIG. **13**) is integrally molded with the sensor cover **12** to be connected with an electrical connector (not shown).

The driving motor **3** is an electrically driven actuator integrally connected with the power-supply terminals that is provided in the sensor cover **12** or the substantially cylindrical shaped motor housing part **7**. When the driving motor **3** is energized, its motor shaft (not shown) is rotated in its forward direction or in its reverse direction. The driving motor **3** has a front-end frame **19** screwed onto a protrusion **21** that is provided in the motor housing part **7** or the gearbox part **11** using a fastening member **20** such as a screw. Thus, the driving motor **3** is received in the motor housing part **7**. A cushion member such as a blade spring can be provided between a rear-end frame of the driving motor **3** and a bottom wall surface of the motor housing part **7** in order to insulate the driving motor **3** from vibration of the engine **80**. Another cushion member can be provided between an end yoke (not shown) of the driving motor **3** and a bottom wall surface of the motor housing part **7**. Alternatively, an insulation member can be provided instead of the cushion member for enhancing vibration resistant performance of the driving motor **3**.

The reduction gears **300** reduce rotation speed of the driving motor **3** by a predetermined reduction gear ratio. The reduction gears **300** (valve driving means, power transmission unit) is constructed with a pinion gear **22**, a middle reduction gear **23** and the valve gear **13** for driving the throttle shaft **2** that rotates the throttle valve **1**. The pinion gear **22** is secured to the outer periphery of the motor shaft of the driving motor **3**. The middle reduction gear **23** engages with the pinion gear **22** to be rotated by the pinion gear **22**. The valve gear **13** engages with the middle reduction gear **23** to be rotated by the middle reduction gear **23**.

The pinion gear **22** is made of a metallic material, and is integrally formed with the motor shaft of the driving motor **3** to be in a predetermined shape, so that the pinion gear **22** serves as a motor gear that integrally rotates with the motor shaft of the driving motor **3**. The middle reduction gear **23** is formed to be in a predetermined shape of a resinous material, and is rotatably provided onto the outer periphery of the supporting shaft **24** that serves as a rotation center of the middle reduction gear **23**. The middle reduction gear **23** is constructed with a large gear part **25**, which engages with the pinion gear **22** of the motor shaft, and a small gear part **26** that engages with the valve gear **13**. The supporting shaft **24** is integrally molded with the bottom wall of the gearbox part **11** of the throttle body **5**. An end part of the supporting shaft **24** engages with a recess portion formed in the inner wall of the sensor cover **12**.

The valve gear **13** is integrally molded to be in a predetermined substantially cylindrical shape of a resinous material. Gear teeth (teeth part) **27** are integrally formed in the outer periphery of the valve gear **13** to engage with the small gear part **26** of the middle reduction gear **23**. A cylindrical part (not shown) is integrally molded with the valve gear **13** on the side of the bore wall part **6** to protrude in the left direction in FIG. **1**. The outer periphery of the cylindrical part (spring inner periphery guide) of the valve gear **13** supports the diametrically inner periphery of the coil spring **4**. A full-close stopper portion **28** is integrally formed with the valve gear **13** on one circumferentially end plane in the outer periphery of the valve gear **13**, i.e., the gear teeth **27**. The full-close stopper portion **28** hooks to the full-close stopper **17** of the gearbox part **11**, when the throttle valve **1** is in the idling position, i.e., full close position.

The coil spring **4** is provided on the outer peripheral side of the metallic shaft part **16** of the throttle shaft **2**. One end part of the coil spring **4** on the left side in FIG. **1** is supported by a body side hook (not shown) provided on the outer wall **6***a* of the bore wall part **6** of the throttle body **5**, i.e., bottom wall of the gearbox part **11**. The other end part of the coil spring **4** on the right side in FIG. **1** is supported by a gear side hook (not shown) provided on a plane of the valve gear **13** that is located on the side of the bore wall part **6**.

The throttle body **5** is a throttle housing that includes the substantially cylindrical-shaped bore wall part **6** internally forming a circular-shaped intake passage, through which intake air flows into the engine **80**. The bore wall part **6** internally receives the disc-shaped throttle valve **1**, such that the throttle valve **1** can open and close the circular-shaped intake passage of the bore wall part **6**. The bore wall part **6** rotatably receives the throttle valve **1** in the intake passage (bore), such that the throttle valve **1** can rotate from the full close position to the full open position. The throttle body **5** is screwed onto an intake manifold of the engine **80** using a fasting bolt or a screw (not shown).

As shown in FIG. **3**, the bore wall part **6** of the throttle body **5** is formed in a predetermined shape that has a double-pipe structure, in which a substantially cylindrical-shaped bore outer pipe **32** is arranged on the diametrically outer side of a substantially cylindrical-shaped bore inner pipe **31**. The bore inner pipe **31** is an internal side cylindrical part that forms an internal periphery. The bore outer pipe **32** is an external side cylindrical part that forms an outer member. The bore wall part **6** of the throttle body **5** is made of a thermo stable resinous material, such as PPS, PBTG30, PA, PP or PEI. The bore inner pipe **31** and the bore outer pipe **32** have an intake-air inlet part (air intake passage) and an intake-air outlet part (air intake passage). Intake air drawn from an air cleaner (not shown) passes through an intake pipe (not shown), the intake-air inlet part and the intake-air outlet part of the bore wall part **6**. Subsequently, the intake air flows into a surge tank of the engine **80** or the intake manifold. The bore inner pipe **31** and the bore outer pipe **32** are integrally molded with each other. The bore inner pipe **31** and the bore outer pipe **32** have a substantially the same inner diameter and a substantially the same outer diameter along with the intake airflow direction, i.e., the direction from the upper side to the lower side in the vertical direction of FIG. **1**.

The motor housing part **7**, which receives the driving motor **3**, is integrally molded of the resinous material with the bore wall part **6** via plural plate-shaped connecting members **9** to construct the throttle body **5**. The motor housing part **7** is arranged in parallel with the bore wall part **6**. That is, the motor housing part **7** is in parallel with the bore wall part **6** with respect to the gearbox part **11** in the throttle body **5**. The motor housing part **7** is arranged on the radially outer side of the sidewall face **6***a* of the bore outer pipe **32** of the bore wall part **6** having the double-pipe structure, with respect to the central axial direction of the bore wall part **6**. The motor housing part **7** is integrally molded of the resinous material with the gearbox part **11**. Specifically, the motor housing part **7** is integrally molded with the end face of the gearbox part **11** located on the left side in FIG. **1**. The gearbox part **11** has a chamber for rotatably receiving the reduction gears **300**. The motor housing part **7** has a substantially cylindrical sidewall part **41** and a substantially circular shaped bottom wall part **42**. The sidewall part **41** extends from the left side face of the gearbox part **11** in the left direction in FIG. **1**. The bottom wall part **42** plugs the opening side of the sidewall part **41** on the left side in FIG. **1**. The central axis of the sidewall part **41** of the motor housing part **7** is arranged substantially in parallel with the axis of the throttle shaft **2**, i.e., rotation axis of the throttle valve **1**. Besides, the central axis of the sidewall part **41** of the motor housing part **7** is arranged substantially perpendicularly to the central axis of the bore inner pipe **31** of the bore wall part **6**.

The plural plate-shaped connecting members **9**, which has a rib structure, are integrally molded of the resinous material with the bore outer pipe **32** of the bore wall part **6** and the motor housing part **7**. The plural plate-shaped connecting members **9** protrude from the sidewall face **6***a* of the bore outer pipe **32** of the bore wall part **6**, and connect to the sidewall face **7***a* of the sidewall part **36** of the motor housing part **7**. Each of the plural plate-shaped connecting members **9** has flat faces on its both sides in a direction substantially perpendicular to the central axis of the bore outer pipe **32** of the bore wall part **6**. Each of the flat faces of the plural plate-shaped connecting members **9** has substantially the same width and substantially the same length with respect to each other.

The plural plate-shaped connecting members **9** are arranged, such that the thickness direction of the plural plate-shaped connecting members **9** becomes substantially perpendicular to the central axis of the bore outer pipe **32** of the bore wall part **6**. Besides, plural plate-shaped connecting members **9** are arranged substantially in parallel with each other in the direction that is substantially perpendicular to the central axis of the bore outer pipe **32** of the bore wall part **6**.

The bore inner pipe **31** internally has an air intake passage, through which intake air flows to the engine **80**. The throttle valve **1** and the throttle shaft **2** are rotatably provided in the air intake passage of the bore inner pipe **31**. A cylindrical space (annular space) is formed between the bore inner pipe **31** and the bore outer pipe **32**, and the cylindrical space is circumferentially blocked, i.e., partitioned, by an annular connecting part **33** at a substantially longitudinally central section thereof. For instance, the substantially longitudinally central section of the cylindrical space is a section along with a circumferential direction of the throttle valve **1** in the full close position. Namely, the substantially longitudinally central section is a circumferential section of the bore wall part **6** passing through the axial center of the throttle shaft **2**. The annular connecting part **33** connects the outer periphery **31***a* of the bore inner pipe **31** and the inner periphery **32***a* of the bore outer pipe **32**, such that the annular connecting part **33** blocks substantially entirely over the circumferential area of the cylindrical space formed between the bore inner pipe **31** and the bore outer pipe **32**.

In this embodiment, wall thickness, i.e. board thickness (axial board thickness) of the annular connecting part **33** in its axial direction is set to be less than a minimum radial thickness of a portion of the bore inner pipe **31** around the annular connecting part **33**. Besides, wall thickness of the annular connecting part **33** in its axial direction is set to be less than a minimum radial thickness of a portion of the bore outer pipe **32** around the annular connecting part **33**. Besides, the axial board thickness of the annular connecting part **33** is set to be less than a radial thickness, i.e. radial wall thickness of the annular connecting part **33**. Furthermore, radial thickness of the bore outer pipe **32** is set to be greater than the radial thickness of the bore inner pipe **31**.

The cylindrical space between the bore inner pipe **31** and the bore outer pipe **32** located on the axially upstream side with respect to the annular connecting part **33** serves as a blockade recess part (moisture trapping groove) **34** for blocking moisture flowing along with the inner periphery of the intake pipe toward the intake manifold. The cylindrical space between the bore inner pipe **31** and the bore outer pipe **32** located on the axially downstream side with respect to the annular connecting part **33** serves as a blockade recess part (moisture trapping groove) **35** for blocking moisture flowing along with the inner periphery of the intake manifold.

Referring back to FIG. **1**, the bore inner pipe **31** and the bore outer pipe **32** has the substantially cylindrical first valve bearing **41** and the substantially cylindrical second valve bearing (not shown) that are integrally molded of a resinous material. The first valve bearing **41** rotatably supports the first bearing sliding part of the metallic shaft part **16** of the throttle shaft **2** via a dry bearing (not shown). The second valve bearing rotatably supports the second bearing sliding part of the resinous shaft part **15** of the throttle shaft **2**. A circular-shaped first shaft hole **43** is formed in the first valve bearing **41**, and a circular-shaped second shaft hole (not shown) is formed in the second valve bearing. The second valve bearing is integrally molded with the outer wall **6***a* of the bore wall part **6**, i.e., bottom wall of the gearbox part **11** of the throttle body **5**, to be protruded in the right direction in FIG. **1**. The outer periphery of the second valve bearing serves as a spring inner periphery guide (not shown) for supporting the diametrically inner periphery of the coil spring **4**.

In this embodiment, the first valve bearing **41** is connected to the inner periphery **32***a* of the bore outer pipe **32** via the bore inner pipe **31** and the annular connecting part **33**. The first valve bearing **41** is integrally molded of a resinous material with the outer periphery **31***a* of the bore inner pipe **31**. The first valve bearing **41** protrudes from the outer periphery **31***a* of the bore inner pipe **31** in a direction substantially in parallel with the rotation center of the throttle valve **1**, i.e., axial direction of the throttle shaft **2**. A substantially annular recess **44** is formed around the first valve bearing **41** in the circumferential outer periphery of the outer wall **6***a* of the bore outer pipe **32**. A plug (not shown) is provided on the first valve bearing **41** for plugging the opening side of the first valve bearing **41**. The second valve connecting part may be connected to the inner periphery **32***a* of the bore outer pipe **32** via the bore inner pipe **31** and the annular connecting part **33**. Another substantially annular recess may be formed around the second valve bearing.

A stay part **45** is integrally molded of the resinous material on the outer periphery, i.e., outer wall **6***a* of the bore outer pipe **32**. The stay part **45** is connected with a connecting end face of the intake manifold of the engine **80** using a fastening member such as a bolt (not shown), when the throttle body **5** is mounted on the engine **80**. The stay part **45** is provided on the outer wall **6***a* of the bore outer pipe **32** located on the lower end side in FIG. **1**. The stay part **45** radially outwardly protrudes from the surface of the outer wall **6***a* of the bore outer pipe **32**, and has an insertion hole **46** through which the fastening member such as the bolt passes.

As follows, an operation of the electrically controlled throttle apparatus is described. When the driver steps the accelerator pedal of the vehicle, the accelerator position signal, which is transmitted from the accelerator position sensor to the ECU, changes. The ECU controls electric power supplied to the driving motor **3**, so that the motor shaft of the driving motor **3** is rotated and the throttle valve **1** is operated to be in a predetermined position. The torque of the driving motor **3** is transmitted to the valve gear **13** via the pinion gear **22** and the middle reduction gear **23**. Thus, the valve gear **13** rotates by a rotation angle corresponding to the stepping degree of the accelerator pedal, against urging force generated by the coil spring **4**. Therefore, the valve gear **13** rotates, and the throttle shaft **2** also rotates by the same angle as the rotation angle of the valve gear **13**, so that the throttle valve **1** rotates from its full close position toward its full open position in the open direction. As a result, the air intake passage formed in the bore inner pipe **31** of the bore wall part **6** of the throttle body **5** is opened by a predetermined degree, so that rotation speed of the engine **80** is changed to be a rotation speed corresponding to the stepped degree of the accelerator pedal by the driver.

By contrast, when the driver releases the accelerator pedal, the throttle valve **1**, the throttle shaft **2**, the valve gear **13** and the like return to an initial position of the throttle valve **1** by urging force of the coil spring **4**. The initial position of the throttle valve **1** is an idling position or the full close position. Alternatively, when the driver releases the accelerator pedal, the value of the accelerator position signal transmitted by the accelerator position sensor becomes substantially 0%. Therefore, in this situation, the ECU can supply electric power to the driving motor **3** in order to rotate the motor shaft of the driving motor **3** in its reverse direction, so that the throttle valve **1** is controlled at its full close position. In this case, the throttle valve **1** can be rotated in the close direction by the driving motor **3**.

The throttle valve **1** rotates in the close direction by urging force of the coil spring **4** until the full-close stopper portion **28** provided on the valve gear **13** contacts the full-close stopper **17** integrally molded on the inner wall of the gearbox part **11** of the throttle body **5**. Here, the close direction is a direction, in which the throttle valve **1** closes the air intake passage by rotating from the full open position to the full close position. Rotation of the throttle valve **1** is restricted by the full-close stopper **17** at the full close position of the throttle valve **1**. Therefore, the throttle valve **1** is maintained in the predetermined full close position, i.e., idling position, in the air intake passage formed in the bore inner pipe **31** of the bore wall part **6** of the throttle body **5**. Thus, the air intake passage connected to the engine **80** is substantially closed, so that rotation speed of the engine **80** is set at a predetermined idling speed.

In the electrically controlled throttle apparatus, the bore wall part **6** of the throttle body **5** has a double pipe structure. The axial board thickness of the annular connecting part **33** is set to be less than the minimum radial thickness of a portion of the bore inner pipe **31** around the annular connecting part **33** and the minimum radial thickness of a portion of the bore outer pipe **32** around the annular connecting part **33**. Besides, the axial board thickness of the annular connecting part **33** is set to be less than the radial thickness, i.e. radial wall thickness of the annular connecting part **33**. Furthermore, radial thickness of the bore outer pipe **32** is set to be greater than the radial thickness of the bore inner pipe **31**. Thus, the radial thickness of the annular connecting part **33** of the bore wall part **6** becomes large, and the axial board thickness of the annular connecting part **33** becomes small. Therefore, rigidity and strength of the annular connecting part **33** largely decreases, so that the annular connecting part **33** can be flexibly deformed, and contraction of the bore outer pipe **32** occurred in its molding process does not have a large influence to the bore inner pipe **31**. Therefore, the inner periphery **8** of the bore inner wall **31** can be restricted from being deformed.

The substantially annular recess **44** is formed around the first valve bearing **41** in the circumferential outer periphery of the bore outer pipe **32**. The first valve bearing **41** is connected to the inner periphery **32***a* of the bore outer pipe **32** via the bore inner pipe **31** and the annular connecting part **33**. The sidewall **7***a* of the sidewall part **36** of the motor housing part **7** connects to the sidewall **6***a* of the bore outer pipe **32** via plural plate-shaped connecting members **9**. That is, the first valve bearing **41** is not directly connected to the outer wall (sidewall **6***a*) of the bore outer pipe **32**, and the motor housing part **7** is not directly connected to the sidewall **6***a* of the bore outer pipe **32**. Therefore, the bore outer pipe **32** is not apt to be largely affected by contraction of the motor housing part **7**. Besides, the bore inner pipe **31** is not apt to be largely affected by contraction of the bore outer pipe **32**. Thus, the inner periphery **8** of the bore inner wall **31** can be further restricted from deformation caused by contraction of the motor housing part **7** and bore outer pipe **32**.

In the electrically controlled throttle apparatus of the present invention, circularity of the inner periphery **8** of the bore inner pipe **31** of the bore wall part **6** can be restricted from degradation due to contraction of a portion around the motor housing **7** and a portion around the bore outer pipe **32**, compared with the conventional electrically controlled throttle apparatus shown in FIGS. **13** and **14**. Therefore, circularity of the inner periphery (bore inner periphery) **8** of the bore inner pipe **31** of the bore wall part **6** can be maintained at a predetermined state. Thus, interference between the throttle valve **1** and the bore inner pipe **31** of the bore wall part **6** can be restricted over a rotation range (rotation angle range) of the throttle valve **1** from its full close position to its full open position.

Furthermore, a gap, which is formed between the cylindrical inner periphery **8** of the bore inner pipe **31** of the bore wall part **6** and the outer circumferential periphery of the throttle valve **1**, can be set at a predetermined degree when the throttle valve **1** is in its full close position in the idling operation. Accordingly, airtightness can be maintained when the throttle valve **1** is in the full close position, and leakage of intake air in the idling operation can be decreased. The amount of fuel, for instance gasoline, consumed in the engine **80** is controlled in accordance with a flow amount of intake air. Accordingly, reduction of the leakage of intake air in the idling operation contributes to improvement of fuel efficiency of the vehicle.

Furthermore, the same resinous material such as a thermo plastic, e.g., PPS or PBT may be used for molding the bore wall part **6** having the double-pipe structure, the throttle body **5** including the motor housing part **7** and the resinous disc part **14** of the throttle valve **1**. Therefore, the gap formed between the circular inner periphery **8** of the bore inner pipe **31** of the bore wall part **6** and the outer circumferential periphery of the resinous disc part **14** of the throttle valve **1** can be restricted from variation caused by a change of ambient temperature due to difference of a linear expansion coefficient of the respective resinous material.

Second Embodiment

As shown in FIG. **4**, an annular connecting part **33** is inclined with respect to the radial direction of the bore wall part **6** by a predetermined angle in the second embodiment. Specifically, the circumferentially end portion of the annular connecting part **33** is inclined in the downstream direction of intake air. Thus, rigidity and strength of the annular connecting part **33** can be decreased, and the annular connecting part **33** can be flexibly deformed. Thus, the inner periphery **8** of the bore inner pipe **31** can be restricted from deformation. Here, the circumferentially end portion may be inclined in the upstream direction of intake air.

The annular connecting part **33** connects the outer periphery **31***a* of the bore inner pipe **31** and the inner periphery **32***a* of the bore outer pipe **32**, such that the annular connecting part **33** partitions substantially entirely over the circumferential area of the cylindrical space formed between the bore inner pipe **31** and the bore outer pipe **32**. The annular connecting part **33** circumferentially blocks the cylindrical space at a substantially longitudinally central section thereof, i.e., a section along with a circumferential direction of the throttle valve **1** in its full close position.

Third Embodiment

As shown in FIG. **5**, a circumferential portion of an annular connecting part **33**, for instance its substantially radially middle portion is circumferentially bent, so that the cross-section of the annular connecting part **33** in its radial direction becomes to be in an elbow-shape, i.e., angle-shape. Alternatively, the circumferential portion of the annular connecting part **33** can be bent, such that the cross-section of the annular connecting part **33** in its radial direction becomes to be in an arch-shape or S-shape. Thus, rigidity and strength of the annular connecting part **33** can be decreased, so that the inner periphery **8** of the bore inner pipe **31** can be restricted from deformation.

Fourth Embodiment

As shown in FIG. **6**, the electrically controlled throttle apparatus in the fourth embodiment has a coil spring **4** constructed with a first spring part (return spring) **51** and a second spring part (default spring) **52**. The return spring **51** serves as a returner spring and the default spring **52** serves as an opener spring. The return spring **51** and the default spring **52** are integrated into one coil spring (valve forcing means) **4** that urges a throttle valve **1** in the close direction and in the open direction of the throttle valve **1**. The coil spring **4** is arranged between the outer wall **6***a* of the bore wall part **6**, i.e., bottom wall of the gearbox part **11** and a plane of the valve gear **13** that is located on the side of the bore wall part **6**. A connecting member between the return spring **51** and the default spring **52** is bent to be in a substantially U-shape to serve as a U-shaped hook part **54** supported by a middle stopper member **53**. Both sides of the coil spring **4** are wound in different directions from each other. That is, the return spring **51** is wound in one direction, and the default spring **52** is wound in the opposite direction with respect to the winding direction of the return spring **51**.

A boss-shaped middle position stopper (not shown) is provided in the gearbox part **11** of the throttle body **5**, such that the middle position stopper internally protrudes in the gearbox part **11**. A middle stopper member **53** (adjust screw) is screwed into the middle position stopper for mechanically maintaining the throttle valve **1** at a predetermined middle position using urging force of the return spring **51** and urging force of the default spring **52** when power supplied to the driving motor **3** is terminated. The urging force of the return spring **51** and the urging force of the default spring **52** are applied in different directions from each other. The predetermined middle position of the throttle valve **1** is a position between the full close position and the full open position. A cylindrical spring inner periphery guide **55** is integrally formed with the outer wall **6***a* of the bore wall part **6**, i.e., bottom wall of the gearbox part **11** of the throttle body **5**, to be protruded in the right direction in FIG. **6**. The outer periphery of the spring inner periphery guide **55** supports the diametrically inner periphery of the coil spring **4**. Another cylindrical spring inner periphery guide **56** is integrally formed with the plane of the valve gear **13** that is located on the side of the bore wall part **6**. The cylindrical spring inner periphery guide **56** protrudes in the left direction in FIG. **6**. The outer periphery of the spring inner periphery guide **56** supports the diametrically inner periphery of the coil spring **4**.

An opener member **57** is integrally molded of a resinous material with the valve gear **13** in this embodiment. The opener member **57** is located on the side of the bore wall part **6** with respect to the valve gear **13**, and is urged by the default spring **52** from the full close position toward the middle position in the open direction. A gear-side hook (second hooking part) **61**, a hooking part **62** and slip restricting guides **63** are integrally formed with the opener member **57**.

The gear-side hook **61** hooks to one end of the default spring **52** of the coil spring **4** in the right end in FIG. **6**. The hooking part **62** detachably hooks to the U-shaped hook part **54** connecting the return spring **51** and the default spring **52**. The slip restricting guides **63** are arranged near the hooking part **62** for restricting movement of the U-shaped hook part **54** in the axial direction of the coil spring **4**.

A spring body-side hook (first hooked part) **65** is provided on one end side of the return spring **51** of the coil spring **4**, which is located on the side of the bore wall part **6** on the left side in FIG. **6**. The spring body-side hook **65** hooks to a body-side hook **64** (first hooking part) that is integrally formed with the outer wall **6***a* of the bore wall part **6**, i.e., bottom wall of the gearbox part **11** of the throttle body **5**. A spring gear-side hook (second hooked part) **66** is provided on the side of the default spring **52** of the coil spring **4**, which is located on the side of the valve gear **13**, i.e., on the right side in FIG. **6**. The spring gear-side hook **66** hooks to the gear-side hook (second hooking part) **61** of the opener member **57**.

In the fourth embodiment, the throttle valve **1** is formed of a metallic material or a resinous material to be in a substantially disc-shape. The throttle valve **1** is inserted into a valve insertion hole (not shown) formed in a valve supporting portion of a throttle shaft **2**, and screwed onto the throttle shaft **2** using a fastening member **67**, such as a screw. The throttle shaft **2** is formed of a metallic material or the like to be in a round-bar shape, for example. Both of the end sides of the throttle shaft **2** is rotatably supported by the first valve bearing **41** and the second valve bearing of the bore wall part **6** of the throttle body **5** to be slidable each other. Therefore, the throttle valve **1** and the throttle shaft **2** can be integrally rotated.

As follows, an operation of the electrically controlled throttle apparatus, when power supplied to the driving motor **3** is terminated, is described. The hooking part **62** of the opener member **57** contacts the U-shaped hook part **54** of the coil spring **4**, while the opener member **57** is inserted between the connecting end part of the default spring **52**, i.e., the U-shaped hook part **54**, and the spring gear-side hook **66**. In this situation, the hooking part **62** and the U-shaped hook part **54** are urged onto each other by urging force of the return spring **51** and urging force of the default spring **52** used as the opener spring. Here, the return spring **51** returns the throttle valve **1** from its full open position to its full close position via the opener member **57**. The default spring **52** returns the throttle valve **1** from its full close position to its middle position via the opener member **57**. Thus, the throttle valve **1** can be maintained at the middle position, so that a fall back operation, i.e., failsafe operation can be performed when power supplied to the driving motor **3** is terminated.

Fifth Embodiment

As described above, the annular connecting part **33** is formed to be in a thin-walled plate shape that is thinner than the wall thickness of the bore inner pipe **31** and the wall thickness of the bore outer pipe **32**. The radial cross-sectional length of the annular connecting part **33** is elongated to be larger than the axial board thickness of the annular connecting part **33**, so that rigidity and strength of the annular connecting part **33** decreases in the internally connected double pipe structure of the bore wall part **6**.

However, in the above internally connected structure, flow resistance of filler (molten resinous material) may increase in a cavity formed in molding dies for molding the annular connecting part **33**. As a result, flow and filling of the filler in the cavity of the molding dies may become insufficient.

In the first example as shown in FIG. **9**, gates shown by arrows are formed in the cavity of the molding dies on the side of the bore inner pipe **31** for injecting filler (molten resinous material). In this case, flow resistance of the filler increases in a portion of the cavity forming the annular connecting part **33** while the filler flows in the cavity of the molding dies. As a result, the filler does not flow over the cavity of the molding dies, and the filler may be insufficiently filled in the cavity of the molding dies. Accordingly, a short cut (short shot, short mold) A may arise in the bore outer pipe **32**, in the motor housing part **7** and/or the gearbox part **11**.

In the second example as shown in FIG. **10**, gates shown by arrows are formed in the cavity of the molding dies on the side of the bore outer pipe **32**. In this case, flow resistance of the filler also increases in a portion of the cavity forming the annular connecting part **33**, and a short cut B may arise in the bore inner pipe **31**.

In the third example as shown in FIG. **11**, gates shown by arrows are formed in the cavity of the molding dies on the sides of the bore inner pipe **31**, the bore outer pipe **32** and/or the motor housing part **7**. In this case, flow resistance of the filler also increases in a portion of the cavity forming the annular connecting part **33**. Additionally, the filler flows from both sides of the bore outer pipe **32** and the motor housing part **7**, and the filler flowing from both sides may adhere with each other in a portion of the cavity, in which the plural plate-shaped connecting members **9** are molded. Therefore, a weld (weld line) C may arise in the plural plate-shaped connecting members **9** connecting the sidewall **7***a* of the sidewall part **36** of the motor housing part **7** and the sidewall **6***a* of the bore outer pipe **32**. The motor housing part **7** receives a heavy component such as the driving motor **3**. Accordingly, the plural plate-shaped connecting members **9** needs to be strong enough to support heavy components such as the motor housing part **7** and the bore wall part **6** receiving the throttle valve **1**. However, strength of the plural plate-shaped connecting members **9** may decrease due to forming of the weld C.

As shown in FIGS. **8**A and **8**B in the fifth embodiment, a molding process of the throttle body **5** includes a first clamping process and a second clamping process. In the first clamping process, molding dies are clamped with each other to form a first cavity that has an internal volume greater than a volume of the molded throttle body **5**. Specifically, the first cavity has a portion for molding the annular connecting part **33** having an internal volume that is greater than at least a volume of the molded annular connecting part **33**. In the second clamping process, the molding dies are clamped with each other to form a second cavity that has an internal volume substantially the same as the volume of the molded throttle body **5**. Specifically, the first cavity has a portion for molding the annular connecting part **33** having an internal volume that is substantially the same as a volume of the molded annular connecting part **33**, at least. The molding dies can be used in both the first clamping process and the second clamping process. The molding dies include a fixed die **71** and a movable die **72** that have a protrusion and a recession corresponding to the bore inner pipe **31**, the bore outer pipe **32**, the annular connecting part **33** and the like for molding the throttle body **5**. A substantially cylindrical shaped compression core (movable core, slide core, movable die) **73** is received in the movable die **72** to be displaceable with respect to the movable die **72**. The shape of the compression core **73** corresponds to the cylindrical space of the air intake passage formed in the bore wall part **6** on the upstream side of the intake airflow. The compression core **73** is displaced with respect to the fixed die **71** by a compression-core driving apparatus (not shown) constructed with a hydraulic cylinder, an air cylinder or the like.

When the compression core **73** is in an initial position, i.e., before compression as shown in FIG. **8**A, the first cavity is formed among the fixed die **71**, the movable die **72** and the compression core **73**. The first cavity has an internal volume greater than at least a total volume of the bore inner pipe **31**, bore outer pipe **32** and the annular connecting part **33**. When the compression core **73** is displaced to be in a forward position, i.e., after compression as shown in FIG. **8**B, the second cavity is formed among the fixed die **71**, the movable die **72** and the compression core **73**. The second cavity has an internal volume substantially the same as a total volume of the bore inner pipe **31**, bore outer pipe **32** and the annular connecting part **33**. As shown by a stippled section in FIG. **7**, an annular end face **39** of the molten resinous material filled in the portion of the cavity for molding the annular connecting part **33** is compressed by a predetermined compression force. The annular end face **39** is an annular end face of the annular connecting part **33** in its axial direction.

As follows, injection press molding process is described. Referring to FIGS. **7**, **8**A and **8**B, heated thermo plastic (filler), i.e., thermo stable plastic such as PPS or PBT in a molten state is injected into the first cavity formed in the molding dies constructed with the fixed die **71**, the movable die **72** and the compression core **73**. The filler is injected into the first cavity through at least one gate formed in the molding dies, so that the first cavity formed in the molding dies is filled with the filler (molten resinous material), in an injection-filling process.

Subsequently, pressure applied to the filler in the molding dies is gradually increased, and the increased pressure is maintained at a pressure greater than the maximum pressure applied to the injected filler in the injection-filling process. That is, predetermined pressure greater than injection pressure is applied to the filler (molten resinous material) filled in the molding dies. Subsequently, cooling water is introduced into the molding dies. In this situation, the filler contracts (shrinks) in the molding dies due to the cooling process. Therefore, additional filler is injected into the first cavity through at least one gate formed in the molding dies to refill additional filler by an amount equivalent to a reduced volume of the molded filler due to the contraction caused in the cooling process, in a pressure holding process. The gate can be formed in the molding dies on at least one of the side of the bore inner pipe **31**, the side of the bore outer pipe **32** and/or the side of the motor housing part **7**.

As shown in FIG. **8**A, the compression core **73** is fixed in the initial position before the compression, and the molding dies are clamped with each other, in the first clamping process during the injection-filling process and/or the pressure holding process. In this situation, the axial board thickness of the annular connecting part **33** is set to be equal to or greater than the minimum radial wall thickness of the bore inner pipe **31** and the minimum radial wall thickness of the bore outer pipe **32** that are located around the annular connecting part **33**. Therefore, the axial board thickness of the annular connecting part **33** is set to be large in the first cavity during the injection-filling process and/or the pressure holding process, so that flow resistance of the filler (molten resinous material) decreases while the filler flows through the first cavity. Thus, even when a gate is formed in the molding dies on one of the sides of the bore inner pipe **31**, the bore outer pipe **32** and the motor housing part **7**, the bore inner pipe **31**, the bore outer pipe **32** and the motor housing part **7** can be restricted from occurrence of short cut of filler.

Besides, the compression core **73** compresses filler filled in the first cavity formed in the molding dies. Therefore, filler filled in a portion of the cavity forming the bore wall part **6** is extruded from a cavity forming the sidewall **6***a* of the bore outer pipe **32** into a cavity forming the motor housing part **7** via a cavity forming the plural plate-shaped connecting members **9**. Therefore, weld C, which is apt to be formed in the plural plate-shaped connecting members **9**, can be displaced to the side of the motor housing part **7**, so that the plural plate-shaped connecting members **9** can be restricted from internal formation of weld C. Therefore, a portion (e.g., plate-shaped connecting member **9**), which supports both of the motor housing pert **7** receiving the heavy driving motor **3** and the bore outer pipe **32**, can be restricted from internal formation of weld C. Thus, strength of the throttle body **5** can be maintained.

Filler (molten resinous material) is filled into the first cavity by an amount equal to or greater than a predetermined volume, e.g., by 80% of the volume of the first cavity. As shown in FIG. **8**B, at least one gate is closed (gate cut) and the compression core **73** is slid to a forward position (after compression) in a direction, in which the compression core **73** approaches the fixed die **71** to form the second cavity among the fixed die **71**, movable die **72** and the compression core **73** in a compression process during the injection-filling process and/or the pressure holding process. Thus, the annular end face **39** of the annular connecting part **33** is compressed by the compression core **73** in the second cavity. The predetermined volume of the filler filled into the first cavity is less than the internal volume of the first cavity.

An annular end face **38** of the annular connecting part **33** located on the lower end side in FIG. **8**B may be compressed using another compression core (not shown), simultaneously with compressing the annular end face **39**, i.e., compressed portion using the compression core **73**. Here, the annular end face **38** is located on the downstream side of intake airflow, and located on the opposite side of the annular end face **39** with respect to the annular connecting part **33**. The annular end face **39** is located on the upper end in FIG. **8**B, i.e., on the upstream side of intake airflow.

In this situation, the molding dies are clamped with each other and the compression core **73** is slid to the forward position, so that the axial board thickness of the annular connecting part **33** becomes less than the minimum radial thickness of the bore inner pipe **31** and the minimum radial thickness of the bore outer pipe **32** in the second clamping process of the fifth embodiment. Preferably, the molding dies are clamped with each other, so that the axial board thickness of the annular connecting part **33** becomes less than the radial wall thickness of the annular connecting part **33** in the second clamping process. Subsequently, the filler filled in the second cavity of the molding die is taken out, and is cooled to be solidified. Alternatively, the filler filled in the second cavity of the molding die is cooled to be solidified using cooling water or the like, while the filler is received in the second cavity. Thus, the throttle body **5** including the bore wall part **6** having a double pipe structure can be integrally molded of the filler, similarly to the first embodiment.

As a result, the annular connecting part **33**, which connects the bore inner pipe **31** and the bore outer pipe **32**, and each of the plural plate-shaped connecting members **9**, which connects the motor housing part **7** and the bore outer pipe **32**, can be formed to be in a thin-walled elongated plate shape. Besides, the recess **44** can be formed around the first valve bearing **41**, and the first valve bearing **41** can be formed to connect to the inner periphery **32***a* of the bore outer pipe **32** via the bore inner pipe **31** and the annular connecting part **33**. Thus, the inner periphery **8** of the bore inner wall **31** can be restricted from deformation caused by contraction of the motor housing part **7** and bore outer pipe **32**, so that airtightness can be maintained when the throttle valve **1** is in the full close position. Aditionally, the gearbox part **11**, bore outer pipe **32** and the motor housing part **7** can be restricted from occurrence of shortcut A thereof, and the bore inner pipe **31** can be restricted from occurrence of shortcut B thereof. Furthermore, a supporting portion (e.g., connecting members **9**) can be also restricted from formation of weld C thereof, using the above injection press molding process.

Sixth Embodiment

In the sixth embodiment as shown in FIG. **12**, an annular end face **31***a* of the bore inner pipe **31** and/or an annular end face **32***a* of the bore outer pipe **32** of the bore wall part **6** are compressed using a compression core **73**, simultaneously with compressing the annular end face **39** of the annular connecting part **33**.

Each of the annular end face **31***a* of the bore inner pipe **31**, the annular end face **32***a* of the bore outer pipe **32** and the annular end face **39** of the annular connecting part **33** described in the fifth embodiment are compressed portions shown by stippled sections located on the upper end face in FIG. **12**, i.e., on the upstream side of intake airflow. Besides, the annular end face (not shown) on the axially opposite side as the annular end face **32***a* with respect to the bore outer pipe **32** can be compressed using another compression core (not shown), simultaneously with the compression of at least one of the annular end faces **31***a*, **32***a* and **39**. The annular end face (not shown) on the axially opposite side as the annular end face **31***a* with respect to the bore inner pipe **31** can also be compressed using another compression core (not shown), simultaneously with the compression of at least one of the annular end faces **31***a*, **32***a* and **39**. The annular end face on the axially opposite side as the annular end face **32***a* with respect to the bore outer pipe **32** and the annular end face on the axially opposite side as the annular end face **31***a* with respect to the bore outer pipe **31** can also be simultaneously compressed.

In an injection process of the throttle body **5**, a contraction rate of the filler (molten resinous material) may disperse in the bore inner pipe **31** due to orientation of fiber and molecular orientation caused by flow of the filler. However, as described in the fifth and the sixth embodiments, the compression process is added to the injection molding process of the throttle body **5**. Thus, difference of a contraction rate of the filler, which forms the bore inner pipe **31**, can be relaxed, and dispersion of contraction of the filler can be decreased. Therefore, circularity of the bore inner periphery of the bore inner pipe **31** can be maintained.

Specifically, compression stress is applied to at least one of the bore inner pipe **31**, bore outer pipe **32** and the annular circular part **33** in the axial direction thereof. Therefore, internal stress radially working in the bore inner pipe **31**, bore outer pipe **32** and the annular circular part **33** can be uniformed, so that the inner bore pipe **31** can be restricted from deformation in its radial direction.

Other Embodiment

A hall IC or a magnetoresistive element or the like can be used as a noncontact sensor, instead of the hall element. A cylindrical-shaped permanent magnet can be used as a magnetic field source, instead of the separated permanent magnets **10**. A substantially disc-shaped resinous disc part (disc-shaped part) **14** and a substantially cylindrical shaped resinous shaft part (cylindrical-shaped part) **15** can construct a throttle valve (resinous valve) **1**, and only a substantially cylindrical shaped metallic member can construct a throttle shaft (metallic shaft) **2**.

The outer periphery of the valve supporting portion of the throttle shaft **2** can be knurled partially or entirely. That is, a rough surface can be formed on the outer periphery of the valve supporting portion, so that a sticking characteristic (connecting performance) can be enhanced between the inner periphery of the resinous shaft part **15** of the throttle valve **1** and the outer periphery of the valve supporting portion of the throttle shaft **2**. Namely, a serration, notches, grooves or the like are partially or entirely formed on the outer periphery of the valve supporting portion, so that relative displacement are restricted between the throttle valve **1** and the throttle shaft **2** in the axial direction thereof. Thus, the throttle valve **1** can be prevented from being pulled out of the valve supporting portion of the throttle shaft **2**. Alternatively, the cross-section of the valve supporting portion of the throttle shaft **2** can be formed in a substantially circular shape having a bolt width. In this structure, the valve supporting portion of the throttle shaft **2** has substantially parallel flat faces along with its axial direction. Alternatively, the cross-section of the resinous shaft part **15** of the throttle valve **1** can be formed in a substantially cylindrical shape having a bolt width. In this structure, resinous shaft part **15** has substantially parallel flat faces along with its axial direction. In this case, relative displacement can be restricted between the throttle valve **1** and the throttle shaft **2** in the rotation direction thereof. A resinous shaft can be used as the throttle shaft **2**. In this case, the resinous shaft can be integrally molded of a resinous material with the resinous shaft part **15** of the throttle valve **1**, so that the number of components of the throttle valve **1** can be reduced.

The above throttle body **5** may be applied to a throttle apparatus, which does not have a driving motor **3**, used for an internal combustion engine. In this case, a lever part, which is mechanically connected to an accelerator pedal via a wire cable, is provided instead of the valve gear **13** that is provided on the end of the metallic shaft part **16** of the throttle shaft **2**. In this structure, the accelerator position operated by a driver can also be transmitted to the throttle valve **1** and the throttle valve **2**.

A compression core can be provided inside of the fixed die **71** to be displaceable, such that the compression core can approach the movable die **72**, and the compression core can depart from the movable die **72**. Alternatively, compression cores can be respectively provided inside of both the fixed die **71** and the movable die **72**. In this case, the compression core provided inside of the fixed die **71** is displaceable, such that the compression core can approach the movable die **72** and the compression core can depart from the movable die **72**. Besides, the compression core provided inside of the movable die **72** is displaceable, such that the compression core can approach the fixed die **71** and the compression core can depart from the fixed die **71**.

The central axis of the bore inner pipe **31** can be eccentrically arranged with respect to the central axis of the bore outer pipe **32** to construct the bore wall part **6** having an eccentric double-pipe structure. That is, the axial center of the bore inner pipe **31** can be eccentrically arranged on an internally one side of the bore outer pipe **32** in the radial direction of the bore outer pipe **32**, e.g., vertically lower side of the bore outer pipe **32** in its installation condition. Here, the radial direction of the bore wall part **6** is perpendicular to the axial direction of the bore wall part **6**. Alternatively, the axial center of the bore inner pipe **31** can be eccentrically arranged on internally another side of the bore outer pipe **32** in the radial direction of the bore outer pipe **32**, e.g., vertically upper side of the bore outer pipe **32** in its installation condition. Alternatively, the bore wall part **6** of the throttle body **5** may has a single pipe structure.

Radial thickness of the bore outer pipe **32** may be equal to or less than radial thickness of the bore inner pipe **31**. However, the axial board thickness of the annular connecting part **33** is set to be less than the minimum radial thickness of a portion of the bore inner pipe **31** around the annular connecting part **33** and the minimum radial thickness of a portion of the bore outer pipe **32** around the annular connecting part **33**.

The blockade recess parts **34**, **35** are formed between the bore inner pipe **31** and the bore outer pipe **32** for blocking moisture or liquid flowing into the bore wall part **6** from both of the upstream and the downstream sides of the throttle valve **1**. The blockade recess parts **34**, **35** are used to restrict the throttle valve **1** from icing in a cold period such as winter, without additional components, such as an additional piping member for introducing engine-cooling water into the throttle body **5**. Alternatively, only the blockade recess part **34** can be provided in the bore wall part **6** for blocking moisture or liquid flowing from the upper side of the throttle valve **1** into the bore wall part **6** along with the inner periphery of the intake pipe. Thus, the number of the parts of the throttle apparatus can be decreased, so that the throttle apparatus can be downsized, and can be produced at a low cost.

A bypass passage can be provided on the outer peripheral side of the bore outer pipe **32** for bypassing the throttle valve **1**. Furthermore, an idling speed control valve (ISC valve) can be provided in the bypass passage for controlling idling speed of the engine **80** by adjusting a flow amount of air passing through the bypass passage. An outlet port of blowby gas discharged from a positive crankcase ventilator (PCV) or a purge tube connected to a vapor recovery equipment for recovering vaporized gasoline may be connected to the intake pipe located on the upstream side of intake airflow with respect to the bore wall part **6** of the throttle body **5**. In this case, engine oil contained in blowby gas may accumulate to be deposit on the inner wall of the intake pipe. However, in this structure, foreign material such as mist or deposit of blowby gas flowing along with the inner wall of the intake pipe can be blocked by the blockade recess part **34**, so that the throttle valve **1** and the throttle shaft **2** can be restricted from occurrence of a failure.

The throttle body **5** can be integrally formed by resin molding or metal casting. The filler, which is formed to be the throttle body **5**, can be a metallic material such as aluminum alloy or magnesium alloy.

Various modifications and alternations may be made to the above embodiments without departing from the spirit of the present invention.

What is claimed is:

1. A throttle body receiving a throttle valve, the throttle body comprising:

a bore wall part that has a double-pipe structure including:
- an inner pipe that rotatably receives the throttle valve;
- an outer pipe that is arranged on a radially outer side of the inner pipe to define a cylindrical space with an outer periphery of the inner pipe therebetween; and
- an annular connecting part that connects the inner pipe and the outer pipe, such that the annular connecting part partitions substantially entirely over a circumferential area of the cylindrical space defined between the inner pipe and the outer pipe,

wherein

the inner pipe, the outer pipe and the annular connecting part are integrally formed, the annular connecting part has an axial thickness that is less than a minimum thickness of the inner pipe in a radial direction thereof and a minimum thickness of the outer pipe in a radial direction thereof,

the outer pipe has a radial thickness that is greater than a radial thickness of the inner pipe, and

a first portion of the outer pipe, which is on an axially unstream side with respect to the annular connecting part, has a radial thickness that is substantially the same as a radial thickness of a second portion of the outer pipe, which is on an axially downstream side with respect to the annular connecting part.

2. A throttle body receiving a throttle valve, the throttle body comprising:

a bore wall part that has a double-pipe structure including:

an inner pipe that rotatably receives the throttle valve;

an outer pipe that is arranged on a radially outer side of the inner pipe to define a cylindrical space with an outer periphery of the inner pipe; and

an annular connecting part that connects the inner pipe and the outer pipe, such that the annular connecting part partitions substantially entirely over a circumferential area of the cylindrical space defined between the inner pipe and the outer pipe,

wherein

the inner pipe, the outer pipe and the annular connecting part are integrally formed,

the annular connecting part has an axial thickness that is less than a radial thickness of the annular connecting part,

the outer pipe has a radial thickness that is greater than a radial thickness of the inner pipe, and

a first portion of the outer pipe, which is on an axially upstream side with respect to the annular connecting part, has a radial thickness that is substantially the same as a radial thickness of a second portion of the outer pipe, which is on an axially downstream side with respect to the annular connecting part.

3. A throttle body according to claim **1** or **2**, wherein

the bore wall part has a cylindrical valve bearing that is integrally formed to rotatably support an end side of a rotation center of the throttle valve, and

the cylindrical valve bearing is connected to an internal periphery of the outer pipe via the inner pipe and the annular connecting part.

4. A throttle body according to claim **3**, wherein

the valve bearing protrudes from the outer periphery of the inner pipe in a direction substantially parallel to the rotation center of the throttle valve, and

the bore wall part defines a substantially annular recess that is located around the valve bearing to define an annular space between the outer pipe and the valve bearing.

5. A throttle body according to claim **1** or **2**, wherein

one of the bore wall part and the outer pipe has a sidewall, to which a motor housing part is integrally formed, and

the motor housing part receives a motor that rotates the throttle valve.

6. A throttle body according to claim **1** or **2**, wherein the throttle body and the throttle valve are made of a same material.

7. A throttle body according to claim **1** or **2**, wherein the annular connecting part connects the outer periphery of the inner pipe and an inner periphery of the outer pipe.

8. A throttle body according to claim **1** or **2**, wherein the annular connecting part blocks substantially entirely over the circumferential area of the cylindrical space formed between the inner pipe and the outer pipe.

9. A throttle body according to claim **7**, wherein the annular connecting part partially blocks the cylindrical space formed between the inner pipe and the outer pipe.

10. A throttle body according to claim **1** or **2**, wherein

the inner pipe of the bore wall part has a substantially cylindrical inner periphery that defines an intake air passage through which intake air passes, and

the throttle valve opens and closes the intake air passage defined by the inner periphery of the inner pipe of the bore wall part.

11. A throttle body according to claim **1** or **2**, wherein the axial thickness of the annular connecting part is less than the minimum thickness of a portion of the outer pipe, which is located in the vicinity of the annular connecting part, in the radial direction thereof.

12. A throttle body according to claim **1** or **2**, wherein the axial thickness of the annular connecting part is less than the minimum thickness of a portion of the inner pipe, which is located in the vicinity of the annular connecting part, in the radial direction thereof.

13. A throttle body according to claim **1** or **2**, wherein the motor housing part has a substantially cylindrical shape.

* * * * *